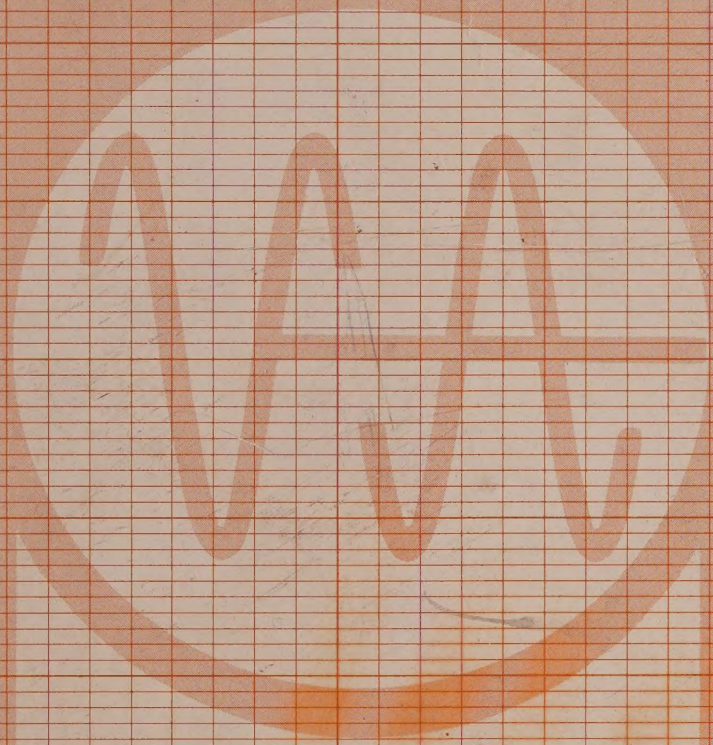
OPERATING AND SERVICE MANUAL

G-10 Graphic Recorder



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A. EQUIPMENT SUPPLIED (Figure 1)

1. Varian Model G-10 Graphic Recorder. (Includes servo unit (1A) and chart drive unit (1B).)
2. Chart roll spindle.
3. Pen cleaner.
4. Pen with plastic reservoir cap.
5. Spare reference cell.
6. Ink.
7. Chart paper.
8. Instruction Manual.

NOTE

The servo unit and the chart drive unit are available as separate items. The servo unit will be supplied with mounting bracket and all items listed above except the chart drive unit and chart paper. The chart drive unit will be supplied with chart paper and Instruction Manual only.

B. ACCESSORIES, SUPPLIES AND OPTIONAL FEATURES

Available accessories, supplies and optional electrical and mechanical features are listed on the data sheet facing page 2.

C. SPECIFICATIONS

Electrical and Mechanical specifications for the instrument are listed on the data sheet facing page 2.

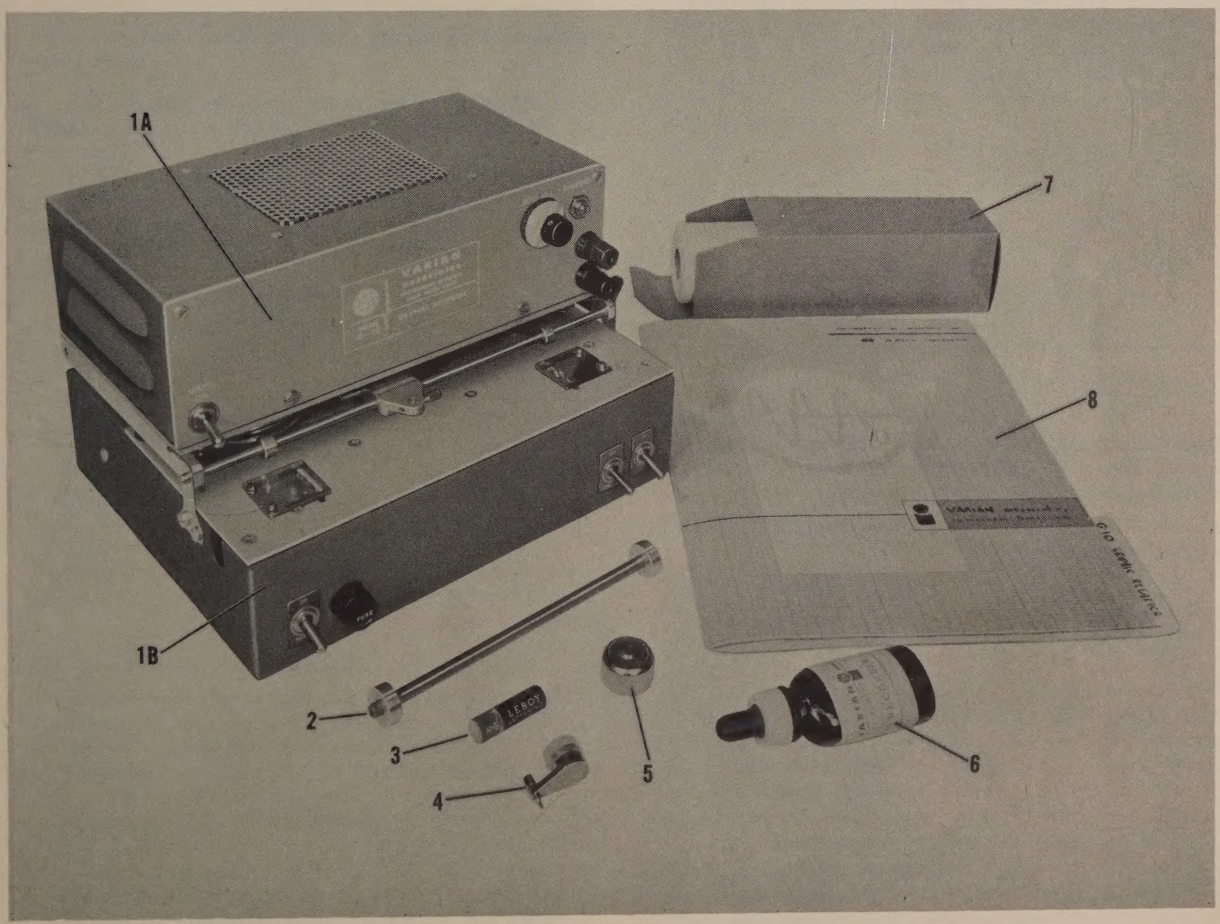

Figure 1. Equipment Supplied

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GRAPHIC RECORDER

DATA SHEET

MODEL
G-10
RECORDER

The Varian Model G-10 Graphic Recorder fulfills the need for a flexible, compact, and moderately-priced instrument for recording phenomena capable of representation by d.c. signals in the millivolt range. The G-10 utilizes the time-proven automatic null-balancing potentiometer principle.

The G-10 Recorder is suitable for local or remote recording and is used . . .

. . . DIRECTLY to measure d.c. millivoltages;
. . . with ATTENUATORS for higher d.c. voltages;
. . . with SHUNTS for d.c. currents of all values;
. . . ACROSS d.c. meters for continuous recording;
. . . with appropriate TRANSDUCERS for measurement of such physical quantities as:

Temperature	Displacement	Speed
Pressure	Weight	Light Intensity
Strain	Force	

The accuracy (limit of error) of the G-10 Recorder results from . . .

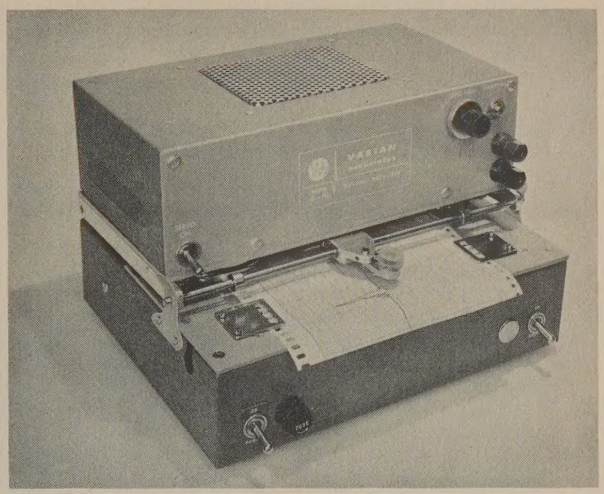
. . . ACCURACY of potentiometer measuring circuit, with calibration based on precision resistors and a mercury reference cell;
. . . STABILITY insured by the use of precision measuring circuit resistors, a reference cell with an excellent discharge characteristic, and an a.c. type servo amplifier;
. . . LINEARITY afforded by high quality measuring slidewire;
. . . SENSITIVTY attained by use of multi-turn measuring slidewire and high-gain servo system, resulting in minimum "dead-zone"

ELECTRICAL FEATURES

Narrow Spans
Full Span Zero Adjustment
Panel Damping Control
Calibration Adjustment
High Permissible Source Resistance

MECHANICAL FEATURES

Rectilinear Coordinate Strip Chart
Chart Accessible for Notations
Dual Chart Speeds (optional)
Provision for External Coupling to Chart-Drive Shaft
Chart Take-Up Unit (optional)
Light Weight
Mechanical Simplicity
Carrying Case (optional)
Compact, Unitized Construction (The G-10 Servo Unit and Chart Drive Unit are available separately).



SPECIFICATIONS

The basic G-10 Recorder has 100 mv. span, 2.5 seconds balancing time, grounded input circuit and one-speed chart-drive unit. Positive-going input signals cause upscale (left-to-right) pen travel. Alternate options are available as tabulated below. Accessories and supplies are described on the back of this sheet.

SPAN (Millivolts Across Chart)	100 mv. (Std.)	50 mv. (Opt.)	10 mv. (Opt.)
Full-scale balancing time*			
Standard	2.5 sec.	2.5 sec.	2.5 sec.
Optional	*1 sec.*	*1 sec.*	*1 sec.*
Limit of error (% of span)	1%	1%	1%
Sensitivity, i.e. "dead-zone" (% of span)	0.5 %	0.5 %	0.5 %
Max. permissible source resistance	0.1 meg.	0.1 meg.	50K

MEASURING CIRCUIT
Standard . . . One side (black terminal) grounded to chassis.
Optional . . . Isolated from chassis for 200 volts d.c. max. with proper source resistance considerations.

POWER REQUIREMENT . . . . 110-120 volts a.c. 58-62 cps, 35 volt-amperes

CHART SPEEDS (synchronous motors)
Standard . . . . . Any single speed from list
Optional . . . . . *Any two speeds from list*
a) 16"/min. c) 4"/min. e) 40"/hour g) 4"/hour
b) 8"/min. d) 2"/min. f) 16"/hour h) 1"/hour

OVERALL DIMENSIONS . 7"high x 10¾"wide x 10"deep
WEIGHT . . . . . 15 pounds
SHIPPING WEIGHT . . . . . 21 pounds

ADDITIONAL DATA
Pen travel Normal . . . . . 5 inches
Maximum . . . . . 7 inches
Servo output torque (stalled) . . . . . 1 pound-inch
Servo motor speed . . . . . ½ rev./second max.
Chart travel per revolution of chart drive shaft . 4 inches
Torque available from chart drive shaft (chart take-up unit not in use) . . 4 oz-inches (min.)

* At 115V line voltage

ACCESSORIES

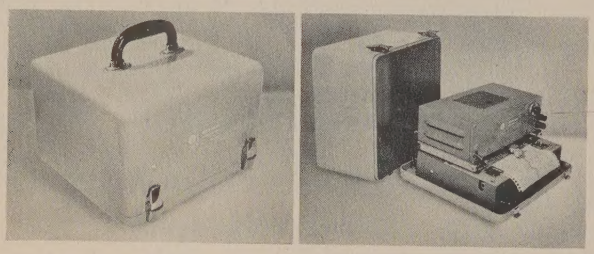
Extra Chart-Drive Motor Assemblies

Spare chart drive motor assemblies are available for any of the chart speeds listed in the specifications on the reverse side. These assemblies include the synchronous motor, mounting-bracket, spur gear, and the a.c. line connector.

Chart Take-Up Unit—Varian Type 222A

The Chart Take-Up Unit can be installed or removed at any time on any G-10 Recorder.

Carrying Case—Varian Type 82



A sturdy, drawn-aluminum carrying case is available for accommodating the G-10 Recorder. The cover is equipped with heavy-duty catches and separable hinges. A convenient handle on the cover facilitates carrying the recorder in its normal operating attitude and prevents possible spilling of ink.

SUPPLIES

Ink

Red ink is supplied in 1 oz. and 4 oz. containers with suitable provision for filling the pen.

Pens—Varian Type 656

Replacement pen assemblies are available.

Reference Cells—Mallory RM-3, or equivalent

Mercury reference cells are available from the Instrument Division, or may be obtained locally.

Chart Paper—Varian Type 5A (Supersedes Type 2)

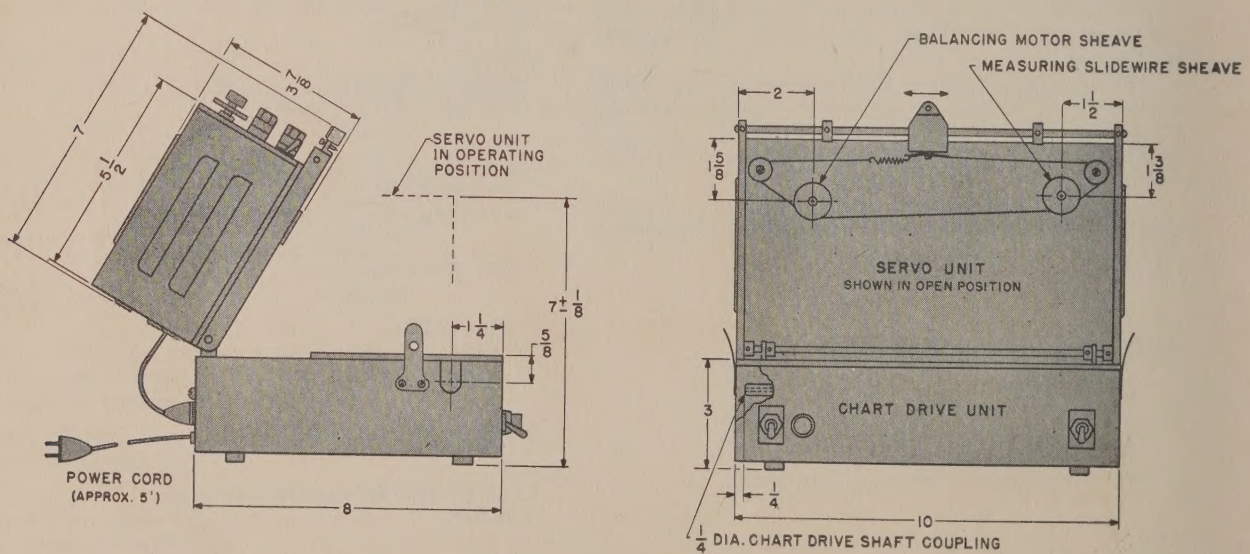
The 5-inch calibrated width is divided into 100 equal divisions, with every tenth line accented. Calibration is 0-100 from left to right. The time ordinate is divided into ¼-inch divisions with heavier lines every inch (no time markings). A roll of chart paper is about 85 feet long.

Varian Type 4A

Similar to type 5A above except time ordinate is divided into 1/10-inch divisions with medium lines every ½ inch and heavy lines every inch.

Card-Type Charts Type 5C

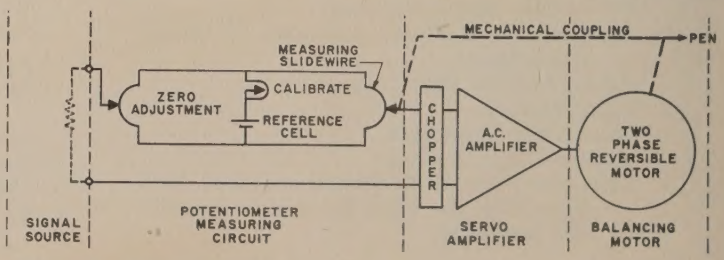
Grid and calibration similar to type 5A above. Printed on manila cards 12" long.



Outline Drawing, Varian Model G-10 Graphic Recorder

The G-10 Graphic Recorder operates on the automatic null-balancing potentiometer principle.

The difference (error signal) between the input voltage and that developed by the measuring circuit is converted by the chopper to an a.c. balancing signal having phase and amplitude determined by polarity and amplitude, respectively, of the error signal. The amplifed balancing signal is applied to one winding of a two phase balancing motor having its other winding excited from the a.c. line. Phasing is such that the motor will drive the measuring slidewire contact in the direction required to reduce the error signal to zero. The slidewire contact position therefore indicates the amplitude of the input signal and the pen is coupled to this contact.



G-10 Operating Principles

Specifications subject to change without notice

A. INSTALLATION

The G-10 is shipped "ready to operate" except for plugging in the power cord and installing the chart paper and pen. Instructions for chart paper installation and pen installation and filling are found on page 5.

Before plugging the instrument into the line, the line power should be checked for agreement with the power input requirements as listed on the instrument nameplate or the data sheet facing page 2. Refer also to B below.

For portable operation, the recorder may be powered from an inverter-type power supply rated to deliver a minimum of 40 watts continuously at the proper voltage and frequency.

CAUTION

As with any electrical measuring instrument, particularly those employing high-gain amplifiers as does the G-10, stray currents can cause inaccuracies. When the recorder is connected to or touching other equipment or metal objects except through the input terminals, stray currents may be introduced. Care should be taken when making multiple connections that errors due to stray currents are not introduced.

B. CONNECTIONS FOR VARIOUS LINE VOLTAGES

(Refer to line voltage specifications on the data sheet facing page 2 and Figures 3, 37 and 40.)

Figure 2. Identification of Controls, Front View

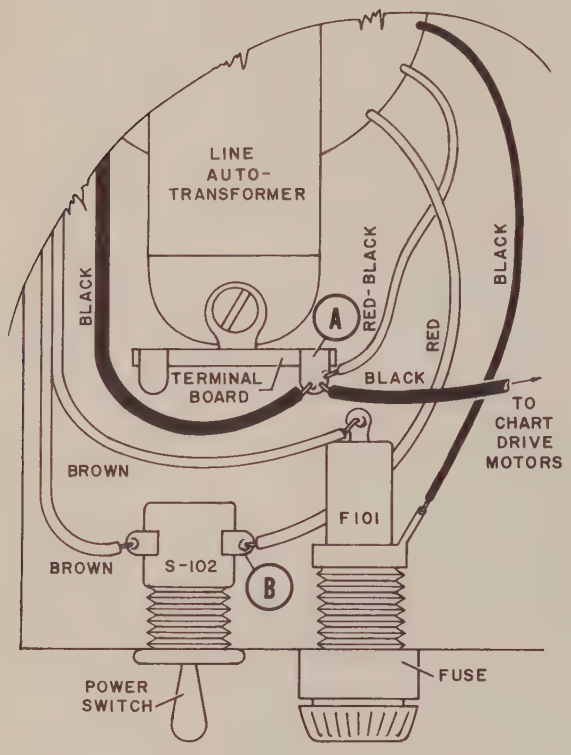


Figure 3. Line Voltage Connections

All instruments suitable for 230/115 volt a.c. operation are shipped from the factory connected for 230 volt operation.

For operation from 115 volt lines, the connections to the line autotransformer must be changed. Figure 3 is a sketch showing connections (in the chart drive unit) for 230 volt a.c. operation. For operation on 115 volts a.c., move the two black wires from point (A) on the terminal board to point (B) on the Power Switch (S-102). No other change is required.

C. IDENTIFICATION AND FUNCTION OF CONTROLS AND TERMINALS

(Refer to Figure 2)

1. POWER "on-off" switch. This is the main power switch. In the "on" position, it supplies heater and plate power to the servo amplifier and makes power available to the chart drive and balancing motors. Removes all power from the instrument when in the "off" position.

2. FUSE holder. Contains a 1.5 ampere fuse which is in series with the a.c. line input.

3. SERVO "on-off" switch. When in the "on" position, supplies power to the line winding of the balancing motor (if the POWER switch is also in the "on" position). When switched to "off" position, places servo in a stand-by condition by disabling only the balancing motor.

4. CHART "on-off" switch. When in the "on" position, supplies power to the chart drive motor (if the POWER switch is also in the "on" position). On the two chart-speed models, two chart motor switches are used, the right-hand switch controlling the high-speed motor. The instrument will not be damaged if both switches are on; chart will simply feed at highest speed.

NOTE

Two chart-speed models beginning with SERIAL 1051 use a SPDT switch instead of two separate chart switches. When switch is in the mid-position both chart motors are off.

5. INPUT terminals. These are the signal input terminals. The upper (red) terminal is positive for right-hand pen travel. Unless the instru-

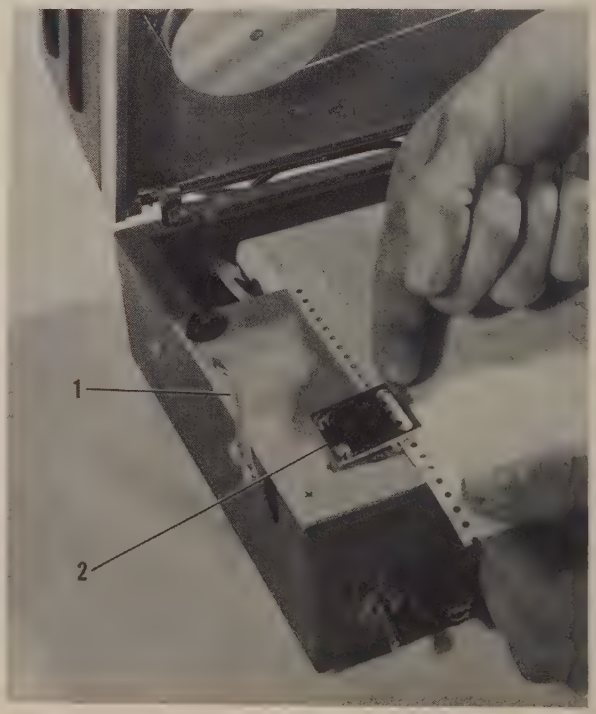


Figure 4. Chart Paper Installation

ment is equipped with Isolated Input, the lower (black) terminal is connected to chassis ground. See input considerations, page 6, for further input information.

6. GROUND TERMINAL. (Isolated input instruments only). A terminal connected to recorder chassis and used to make connections to external grounds.

7. ZERO ADJUST Control. Allows continuous adjustment of pen zero to any point on the chart, thereby permitting positive-going, negative-going or zero-center recording. This control affords about 20% offset (i.e., off-scale zero-set) in either direction. Clockwise rotation moves the pen to the right. Rotating outer ring (7A) clockwise locks the zero adjust knob (7B).

8. DAMPING Control. Allows adjustment to obtain an optimum damping condition for any value of source resistance within specification. Clockwise rotation decreases damping.

9. CALIBRATE Control. A screw driver adjustment located through a hole in the upper left corner of the servo unit, looking at the unit from the rear. Used to adjust the span of the instrument to the rated value and to compensate for reference cell discharge.

D. CONDENSED OPERATING INSTRUCTIONS

1. Check for an adequate supply of chart paper and ink.

2. Plug line cord into appropriate a.c. outlet.

3. Switch on POWER switch.

4. Connect signal source to recorder INPUT terminals.

5. Switch on SERVO switch and adjust DAMPING control for optimum pen response. (Rotate ZERO ADJUST control to observe pen response.)

6. Using ZERO ADJUST control, position pen to the desired zero position.

7. Switch on CHART switch and make recording.

E. DETAILED OPERATING INSTRUCTIONS

1. Installing Chart Paper. (See Figure 4.)

(a) Spread servo unit support clips (1) and tilt servo unit to the rear exposing chart well located in the rear of the chart drive unit.

(b) Remove chart roll spindle by lifting straight up, spreading the spring catches at each end of the chart roll holder if necessary.

(c) Insert the spindle through the chart roll and replace in the chart paper well. As shown in Figure 4, the paper feeds out from the rear and over the top of the roll.

(d) Carefully lift inner ends of chart clamps (2) and insert chart edges underneath the clamps so that sprocket teeth engage perforations. Do not force clamps as they can be raised only about 1/4 inch (6 mm). (See Figure 4.)

2. Installing Pen. (See Figure 5.)

Make certain the pen is clean. (See page 19 for pen care instructions.) Remove the plastic reservoir cap and fill the reservoir with ink. Replace the reservoir cap and insert the pen cleaner into the pen to cause ink to flow to the point. Remove the pen cleaner from the pen.

The pen is installed by loosening the set-screw (1) on the right side of the pen carriage and inserting the pen into the bottom of the hole in the carriage (2) (see Fig. 5). The pen should be adjusted so that the point is perpendicular to the chart-drive plate and is in contact with the chart paper with a slight amount of pressure. The set-screw (1) is then tightened to hold the pen in position.

Figure 5. Pen Installation

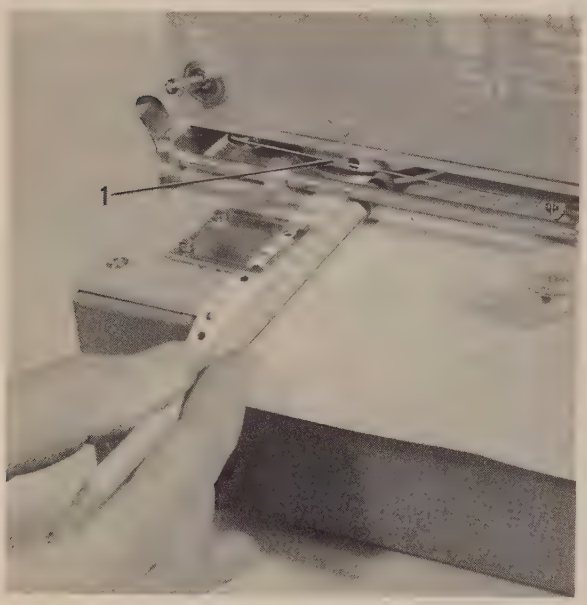


Figure 6A. Photo of "Dead Band" Check

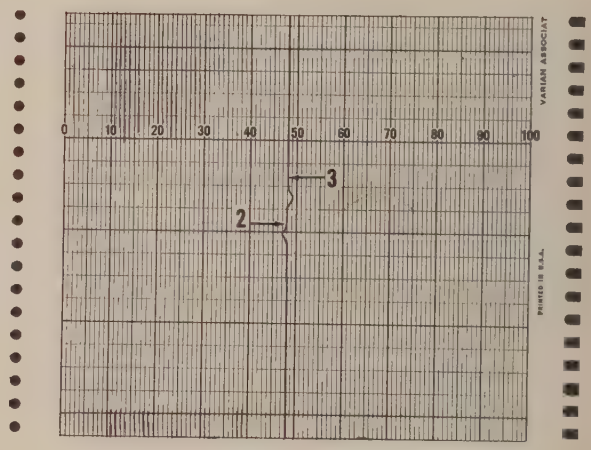


Figure 6B. Sample of "Dead Band" Record

The pen cleaner may be inserted in the pen when making recordings although it is usually not desirable. The plastic reservoir cap should be kept in place so the quick-drying ink will not clog the pen.

3. Input and Grounding Considerations

(a) Input Signal. The input signal should be entirely free from a.c. hum and noise. The presence of hum or noise at the input may saturate the high-gain amplifier, resulting in decreased sensitivity or possible offset.

Positive-going signals connected to the red input terminal cause left-to-right pen travel.

(b) Source Resistance. Since the G-10 recorder employs the null-balancing potentiometer principle, the apparent input resistance approaches infinity when the system is at balance. The input resistance is somewhat lower, however, when the system is not at balance. If the source resistance is kept lower than the maximum permissible value specified on the data sheet, facing page 2, damping can be adjusted and the sensitivity of the instrument will be within specification.

(c) Input Attenuator. An input attenuator is required when recording voltage variations which are in excess of the recorder span. This attenuator need be only a simple voltage divider or, if the user prefers, there are a number of commercially available attenuators that are suitable. When making calculations to determine resistance values for the attenuator, no allowance is required for recorder input resistance since this resistance is extremely high when the recorder is at balance. The resistance arm across the recorder input terminals should not, however, exceed maximum source resistance specifications for the particular instrument. In general, keep this resistance as low as possible.

(d) Grounding. If the recorder has a grounded input, the black terminal is at chassis ground potential. This terminal should be operated as near ground potential as possible to minimize a.c. "pick-up". If the recorder is "floated" above ground, precautions must be taken to isolate the recorder from other objects as well as from operating personnel.

Grounded input recorders should not be connected to or in contact with any equipment or metallic objects except through the input terminals, since other connections or ground loops may introduce inaccuracies.

Isolated input instruments have neither of the input terminals grounded. If the chassis is to be grounded, use the ground terminal and

insure that the ground circuit is free from circulating currents.

Input d.c. levels to a maximum of 200 volts from ground are permitted by the isolated input feature.

If the input signal is "floating" on some d.c. potential (V_F), a certain amount of pen offset can occur.

The maximum offset amounts to approximately 0.03% of span per volt off ground (V_F).

If V_F is constant the offset may be compensated for by adjustment of the ZERO ADJUST control so that no error results. (Adjust ZERO ADJUST control with V_F present.

Please note that the isolated input feature does not afford balanced input. (See Figure 35, page 45.)

4. Performance Check

(a) Turn on the POWER, SERVO and CHART switches, short-circuit the INPUT terminals and rotate the DAMPING control to the full clockwise position. While watching the pen, suddenly rotate the ZERO ADJUST control. The pen should move quickly to the balance position but without overshoot. If overshoot occurs, move DAMPING control counterclockwise until overshoot just disappears.

(b) Abruptly rotate the ZERO ADJUST control to move the pen to the full right position and then to the full left position. The pen should move throughout the entire range of pen travel at a constant velocity (disregarding acceleration and deceleration) and the velocity should be approximately the same in either direction.

(c) Check the "dead band" as follows: (See Figure 6A.)

Position the pen in the operating range. With the INPUT terminals short-circuited rotate DAMPING control full clockwise. Using the eraser-end of a lead pencil rotate the balancing motor sheave (1 in Fig. 6A) so that the pen moves off balance about 1% of the recorder span. Release the sheave (gradually to prevent possible overshoot) and note the point on the chart where the pen comes to rest (2 in Fig. 6B). Using the pencil eraser, rotate the balancing motor sheave to move tne pen in the other direction by 1%. Again, gradually release the sheave and note the displacement (if any) between the new pen position (3 in Fig. 6B) and the position previously noted. This displacement (dead band) should not be more than 1/2% of the recorder span.

(d) If the instrument performs as described above, make damping and zero adjustments (calibrate if necessary) and the unit is ready for operation. If the instrument does not perform as described or other abnormal conditions are observed, consult the Table of Symptoms and Remedies, page 21.

5. Damping Adjustment (See Figure 7.)

(a) Connect the signal source to the recorder; source output should be a steady-state value (zero, if possible). Turn on POWER switch and allow one minute for amplifier warm-up.

(b) Turn on CHART and SERVO switches and abruptly rotate ZERO ADJUST control. Observe the pen response. Repeat until damping condition is determined.

(c) Adjust the DAMPING control for desired pen response. When the control is rotated CW, damping is decreased. Excessive damping (A of Fig. 7) causes the pen to creep into position, while insufficient damping (C of Fig. 7) causes the pen to overshoot before coming to rest. Optimum damping (B of Fig. 7) is between these extremes; the pen will quickly move to the proper position and stop.

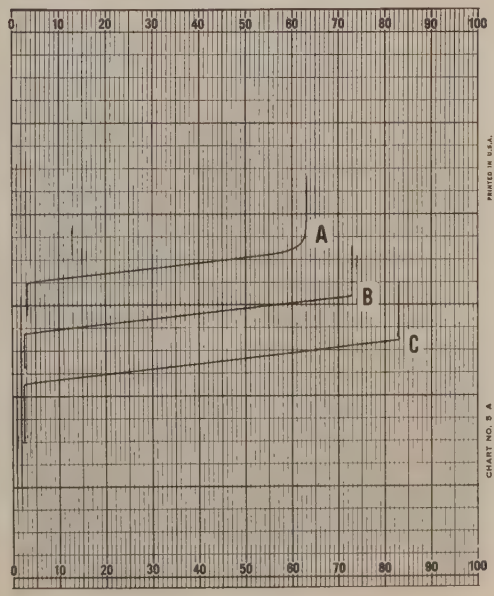


Figure 7. Damping Conditions

Figure 8A. Changing Chart Drive Motor, Top View

6. Zero Adjustment

(a) With the POWER, SERVO and CHART switches turned on and the signal source connected to the INPUT terminals, adjust the input signal level to the desired zero or reference potential.

(b) Rotate the ZERO ADJUST locking ring CCW to unlock the ZERO ADJUST knob.

(c) Rotate the ZERO ADJUST knob to move the pen to the desired zero or reference point on the chart paper. Pen moves to the right when knob is turned CW.

(d) Rotate the locking ring CW to lock the ZERO ADJUST knob in the desired position.

7. Calibration

All G-10 recorders are calibrated at the factory before shipment. The mercury reference cell will discharge at a rate of from one to two percent per month and the cell itself has a service life of from three to four months. Calibration, therefore, should be checked periodically and whenever exact quantitative measurements are to be made. Check calibration as follows:

(a) Turn on the POWER and SERVO switches and allow one minute for the instrument to warm up.

(b) Short-circuit the INPUT terminals and use the ZERO ADJUST control to position the pen on the zero position of the chart.

(c) Remove the short-circuit and connect a source of accurately known voltage to the INPUT terminals. A portable potentiometer, such as the Leeds and Northrup Cat. 8657-C is excellent for this purpose (also see Note). The voltage applied may be equal to the span or can be somewhat less. The source resistance should be less than the maximum permissible value for the recorder. (If a portable potentiometer is used, the galvanometer should be locked or short-circuited so e.m.f.'s generated as the galvanometer moves will not cause difficulties.)

(d) Adjust the CALIBRATE control until the pen indicates the exact value of the input voltage.

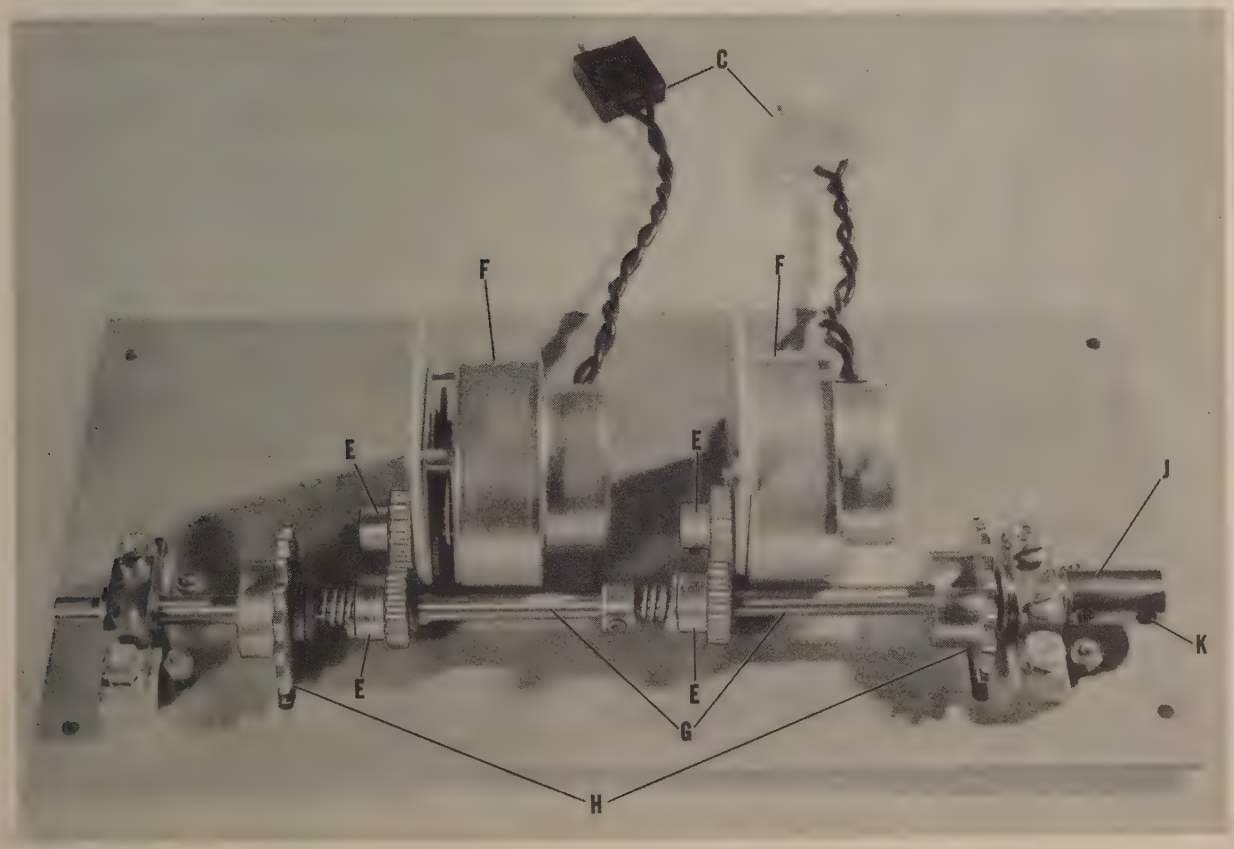


Figure 8B. Changing Chart Drive Motor, Bottom View

NOTE

A spare mercury reference cell may be used to obtain approximate voltages of 100, 50 or 10 millivolts by the use of voltage divider networks having the following resistance values:

100 millivolts	50 millivolts	10 millivolts
12.5K ohms,1%	13K ohms,1%	40K ohms,1%
1K ohms,1%	500 ohms,1%	300 ohms,1%

Apply the cell voltage (approximately 1.34 volts) across the series combination of the two appropriate resistors and connect the recorder input across the smaller resistance. Temporary leads may be soldered to the cell for this application. The voltages thus obtained are accurate enough for many applications. Disconnect the divider circuit from the cell when not being used to avoid undue cell drain.

8. Changing Chart Speeds (See Figure 8A,B)

The chart speed may be changed by changing the chart motor assembly as follows:

(a) Disconnect the main power cord.

(b) Spread servo unit support clips (A in 8A) and tilt servo unit back.

(c) Remove chart paper from chart drive sprockets and rewind on the chart roll.

(d) Remove the chart drive plate by unscrewing the four corner screws (B in 8A) and lifting the plate up. (Plate may have to be turned at an angle before lifting out.)

(e) Unplug the chart drive-motor power cord(s) (C in 8B).

(f) Remove the appropriate screws (D in 8A) holding the motor bracket to the underside of the chart drive plate and remove motor assembly (F in 8B).

(g) Install new chart drive-motor assembly on chart drive plate in reverse order to above. To prevent binding, make certain that the chart drive gears (E in 8B) are loosely meshed and that the motor (F in 8B) does not come in contact with the chart drive shaft (G in 8B). (Positioning of the motor on the mounting bracket may be necessary.) Care should be taken to insure that the motor leads are placed well away from the drive gears and sprockets (H in 8B) to avoid entanglement.

NOTE

Chart paper feeds at the rate of four inches (10.16 cm.) per revolution of the chart drive motor.

9. Externally Coupling to the Chart Drive Shaft

(a) Remove only the chart drive plate as described in paragraph 8 above.

(b) Insert a one-quarter inch (6.3 mm) diameter extension shaft (not supplied) into coupling (J in Figure 8B) and tighten set screw (K in Figure 8B).

(c) Replace chart drive plate assembly.

NOTE

Shaft makes one revolution for four inches (10.16 cm.) of paper feed.

A. GENERAL

The G-10 Graphic Recorder operates on the automatic null-balancing potentiometer principle, long proven to be a most stable, accurate, and reliable method of measurement. The accuracy of the system depends upon the accuracy of the resistors used in the measuring circuit and upon the stability of the reference cell. Accurate resistors are readily obtainable, and the mercury reference cell used has a short-term stability of approximately one part in 10^7 and discharges at a nearly uniform rate of approximately 1-1/2% per month. The effect of cell discharge can be eliminated at any time by adjustment of the calibration potentiometer.

The automatic balancing feature is obtained by continuously detecting and cancelling any difference between the signal voltage and the measuring circuit reference voltage (MEASURING VOLTAGE) by means of a servo balancing system.

The G-10 Recording System consists of the following major parts: Measuring Circuit, Chopper, Amplifier, and Balancing System. A block diagram of the recorder is shown in Figure 9.

B. THEORY OF OPERATION

1. Measuring Circuit

The potentiometer measuring circuit is an adjustable, calibrated source of voltage. This MEASURING VOLTAGE is "bucked against" the input signal voltage and the resultant difference voltage becomes the output "ERROR SIGNAL". Figure 10 shows an analogous system.

If the MEASURING VOLTAGE is adjusted until it has a value equal to the input signal voltage, the ERROR SIGNAL becomes zero. This condition is called "null-balance".

At null-balance, no current flows through the input terminals, and the apparent input resistance thus approaches infinity. This extremely high input resistance permits measurement of the e.m.f. of a source without errors due to internal resistance of the source or external lead resistance (so long as the maximum permissible source resistance is not exceeded). From another viewpoint, the measuring circuit will not "load" the circuit under test.

A simplified version of the measuring circuit used in the G-10 Recorder is shown in Figure 11.

The reference cell current produces an IR drop across the measuring slidewire and the adjustable slidewire contact presents, as the MEASURING VOLTAGE, a portion of this potential between points A and E. When a signal voltage is applied across the input terminals (A and B), the adjustable slidewire contact is moved until the MEASURING VOLTAGE exactly "bucks out" the signal voltage, resulting in zero ERROR SIGNAL (null-balance) at E and F.

Since the measuring slidewire is a linear potentiometer, the MEASURING VOLTAGE developed across section C-D of the slidewire will be proportional to the angular position of the shaft which drives the measuring slidewire adjustable-contact (zero at C; maximum at G).

By use of the calibration potentiometer, the current from the reference cell can be adjusted so that the IR drop across the measuring slidewire has the proper value, thus establishing the desired voltage span.

Addition of a zero-adjust potentiometer to the circuit in Figure 11 results in the circuit shown

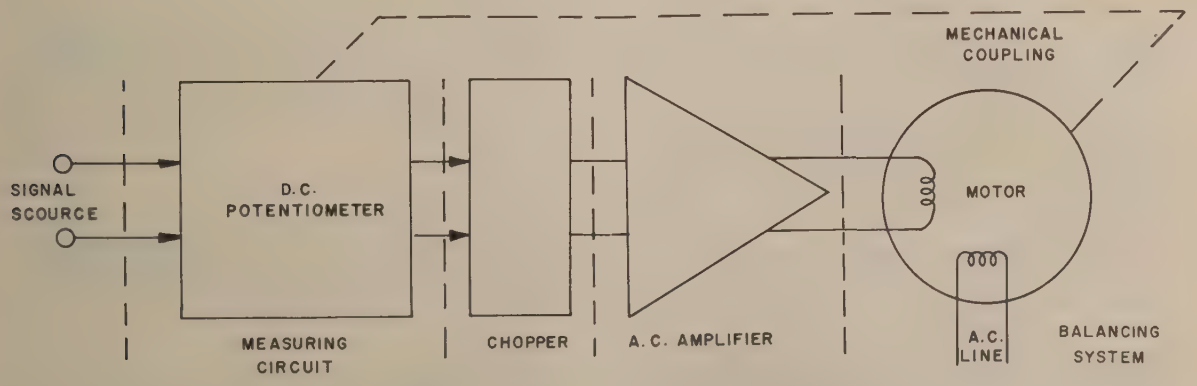


Figure 9. Recorder Block Diagram

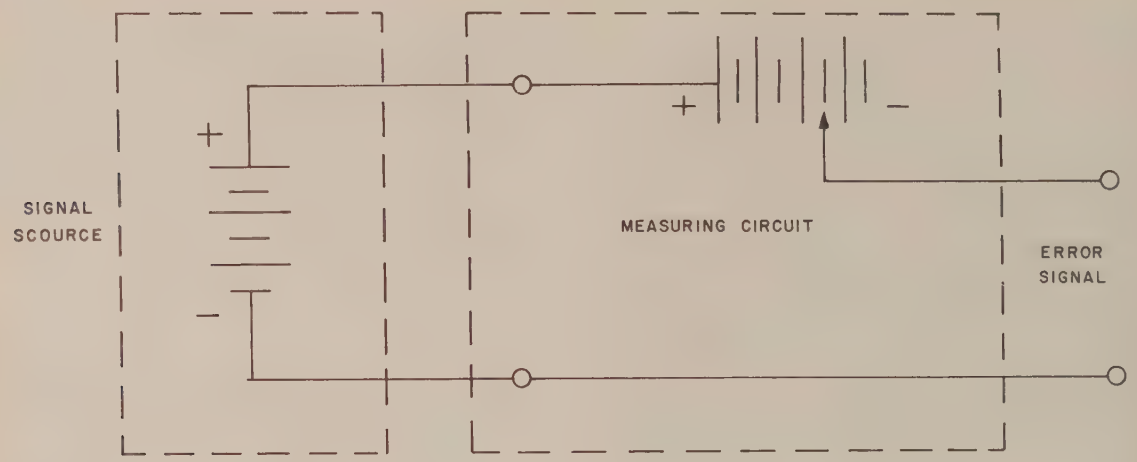


Figure 10. Measuring Circuit Analogy

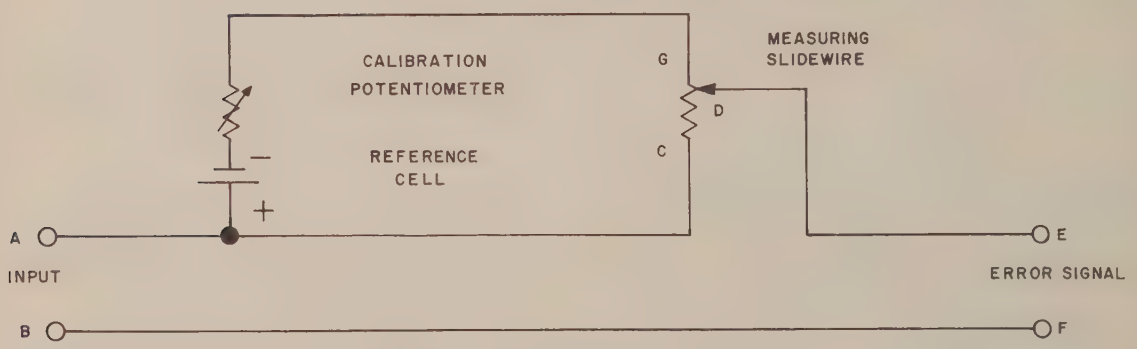


Figure 11. Simplified Measuring Circuit

in Figure 12. The position of the measuring slidewire contact for zero MEASURING VOLTAGE (A-E) is now dependent upon the position of the moveable contact on the zero-adjust potentiometer. In the G-10 Recorder, the zero-adjust potentiometer will allow the zero point to be shifted continuously over the full span of the instrument and also provides for approximately 20% offset at either end of the span.

The actual measuring circuit used in the recorder is shown in Figure 13 (also in Figure 34) except that R101, C101, and C102 have been deleted in Figure 13 for purposes of clarity (their function will be discussed later). Voltage divider network, R105 and R106, allows operation of the measuring slidewire at a high level (approximately 1 volt) with respect to the span of the recorder (100 mv or less). This is done so that the effects of thermal e.m.f.'s generated by the measuring slidewire contact, being a very small fraction of the total slidewire drop, will be virtually eliminated. The MEASURING VOLTAGE appears across R105. The d.c. ERROR SIGNAL appears between points E and F.

If the system is at null-balance, the d.c. ERROR SIGNAL (at E-F) is zero. When the system is not at null-balance the ERROR SIGNAL amplitude is determined by the amount of unbalance and its polarity is determined by the direction of unbalance.

In order to operate the potentiometer measuring circuit as a null-balance device, some means

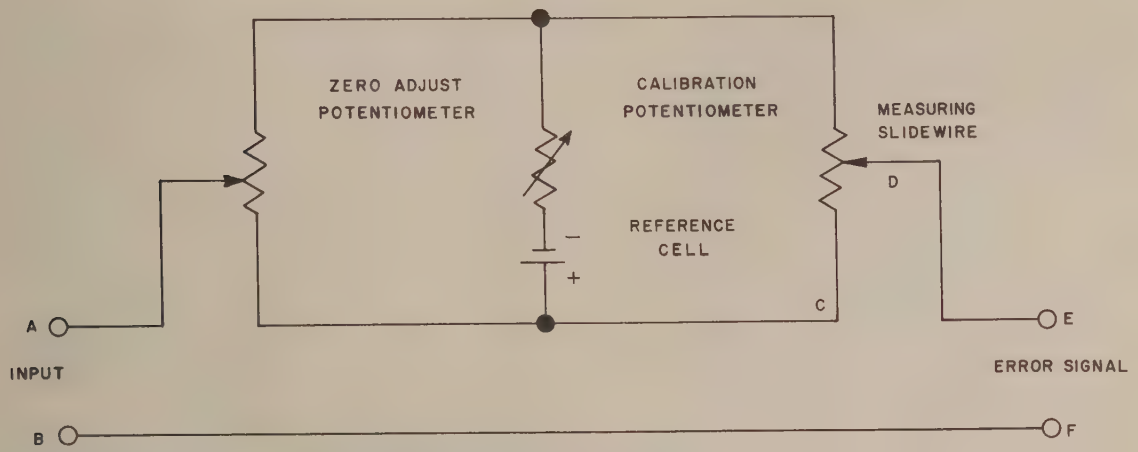


Figure 12. Simplified Measuring Circuit

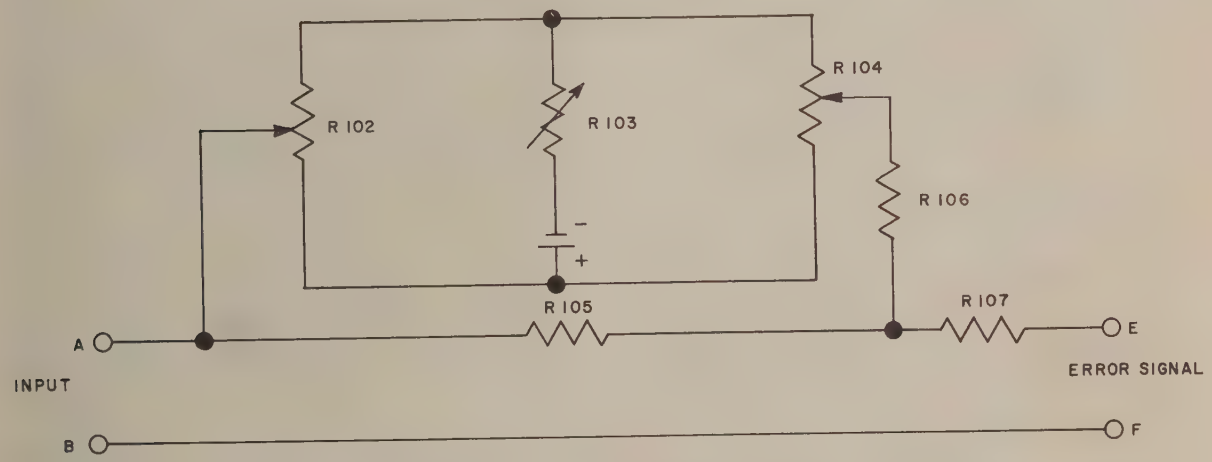


Figure 13. Actual Measuring Circuit

of null-detection is required. This function is performed by the chopper-amplifier-balancing system combination which will be discussed in subsequent sections.

2. Chopper

In order to amplify the ERROR SIGNAL (which may be only a few microvolts), with the required stability and coherence, the signal is converted to a.c. by the chopper as shown in Figure 14.

The chopper operates at the a.c. line frequency, its contacts being open about 50% of the time and closed about 50% of the time (see Figure 14). When the chopper contacts are open, the amplifier "sees" the d.c. ERROR SIGNAL; when the contacts are closed, the amplifier input is short-circuited and the ERROR SIGNAL appears across Resistor R107 in Figure 13 and in A of Figure 14.

If the d.c. ERROR SIGNAL is positive with respect to signal ground, the a.c. signal from the chopper, called the "BALANCING SIGNAL", will be as shown at B of Figure 14 and its amplitude will be equal to the amplitude of the ERROR SIGNAL. On the other hand, if the d.c. ERROR SIGNAL polarity is reversed, the a.c. BALANCING SIGNAL at C of Figure 14 will result (shifted 180° from B of Figure 14).

Thus the BALANCING SIGNAL has a phase determined by the polarity of the ERROR SIGNAL and an amplitude determined by the amplitude of the ERROR SIGNAL.

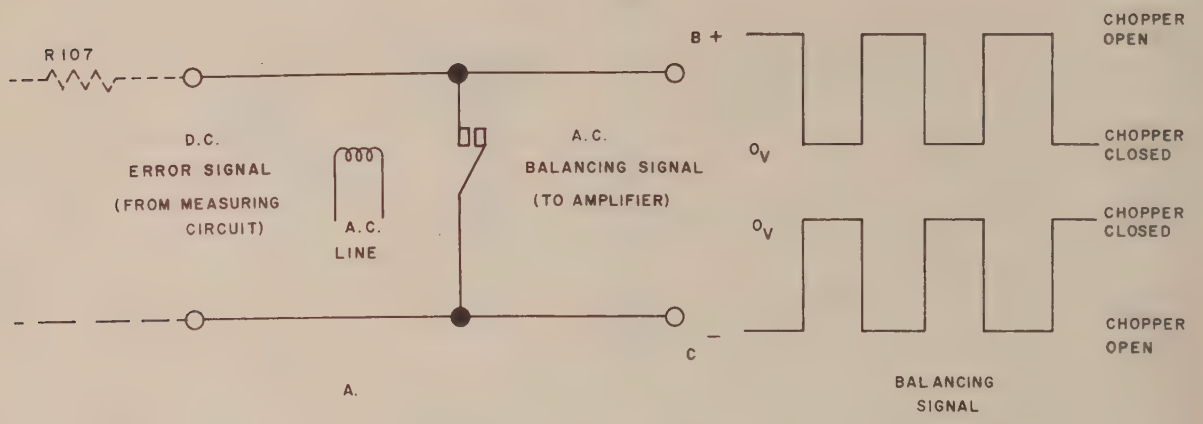


Figure 14. Chopper Operation

3. Amplifier

The a.c. BALANCING SIGNAL is fed to the power amplifier, which consists of V101, V102, and V103 (see Figures 34, 35 and 36).

This amplifier is quite straightforward except that the pass band is quite narrow. It must pass 60 cycles, but not much less, and the upper limit need not be much higher than 60 cycles. The narrow bandpass characteristic is an asset in reducing noise.

The BALANCING SIGNAL is amplified to a suitable level and fed to one winding of the balancing motor.

4. Balancing System

The balancing system is composed of the balancing motor, the damping system, and the mechanical coupling, and operates to drive the measuring slidewire contact to the null-balance point and to position the recording pen on the chart.

(a) Balancing Motor

The balancing motor is a reversible, two-phase induction motor. One winding, called the "line" winding, is excited from the a.c. line and the other winding, called the "control" winding, is excited by the BALANCING SIGNAL from the amplifier. When the current in the "control" winding leads the current in the "line" winding by 90°, the motor will rotate with maximum torque in one direction; if the "control" current is shifted 180° ("control" current lags the current in the "line" winding by 90°), rotation will be in the opposite direction.

Since the motor is a phase-sensitive device (only "control" winding current components in quadrature with the "line" winding current cause rotation) noise or frequencies other than the frequency of the BALANCING SIGNAL (the line frequency) will not cause rotation. The spurious components which would be dissipated as heat in the motor are minimized by the narrow pass band of the amplifier.

The system phasing is adjusted (by means of the phase shift capacitors C115 and C116 in Figure 34, page 43) so that the BALANCING SIGNAL will cause rotation with maximum torque and in the direction required to achieve null-balance.

It is interesting to note that, for maximum torque, the voltages across the "line" and "control" windings of the motor are not in quadrature, but are approximately 40° apart in phase. This is due to a difference in the impedance of the two windings.

When a d.c. ERROR SIGNAL appears, the resulting amplified BALANCING SIGNAL causes the balancing motor to drive the measuring slidewire contact toward the null-balance point. With large ERROR SIGNALS the amplifier output reaches a constant maximum value and the motor rotates at a fixed maximum speed. As the null is approached, the ERROR SIGNAL diminishes and the motor speed is reduced. When null-balance is reached, the ERROR SIGNAL is reduced to zero, the BALANCING SIGNAL becomes zero, and the motor ceases to rotate.

(b) Damping System

If the balancing system is to operate rapidly but without overshoot or undershoot, the sys-

tem damping must be optimized to counteract the effects of inertia. Damping is achieved in the G-10 Recorder system by means of two RC networks, R101 C101 and R106 C102 (See Figure 34).

These networks derive voltages approximately proportional to the rates of change of the signal voltage and the MEASURING VOLTAGE and these damping voltages are added algebraically to the ERROR SIGNAL. As the system approaches balance, braking is applied by setting up a false null condition in advance of the actual null. At balance, since rates become zero (relatively if not actually), the damping voltage is also zero.

When a change in the input voltage occurs, the damping voltages assist in accelerating the system by increasing the apparent unbalance. The damping potentiometer (R101, Fig. 34) can be considered to be a part of the source resistance and is made continuously adjustable to permit adjustment of the damping for external source resistances from zero to the maximum values shown on the data sheet, facing page 2.

(c) Mechanical Coupling.

The mechanical coupling links the balancing motor to the measuring slidewire contact and the recording pen by means of sheaves and a flexible drive cable (see Figure 15). The drive cable (A) is attached securely to the measuring slidewire sheave (B) and the pen carriage (C). It is driven from the balancing motor sheave (D) by friction only and no damage will result

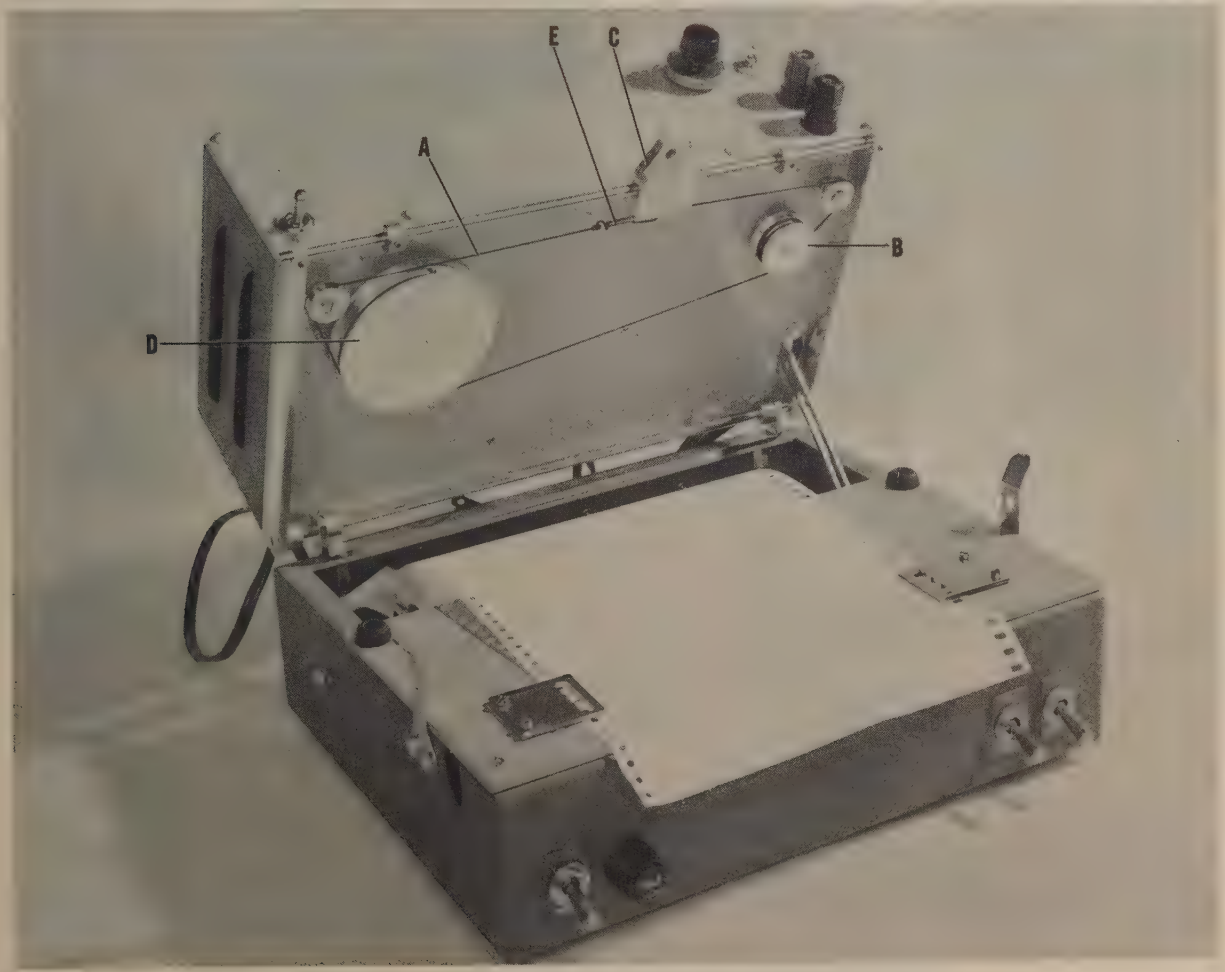


Figure 15. Servo Underside

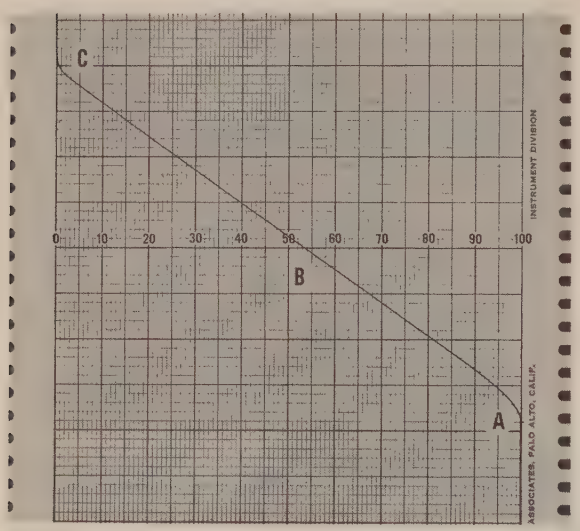


Figure 16. Balancing Time

to the system if the balancing motor continues to turn when the pen has been driven to the limit. Spring (E) is used to keep tension on the drive cable.

C. BALANCING TIME

The full-scale balancing time for the G-10 recorder is the time required for the instrument to come within 0.5% of balance when a full span step function is applied. Figure 16 illustrates a typical curve plotted by a one-second response instrument on paper being fed at the rate of four inches per second. Curves for the 2-1/2 second response instrument are similar and can be represented by multiplying the time ordinate units by a factor of 2-1/2.

It can be seen from Figure 16 that there are three distinct portions to the curve, (A) the accelerating time, (B) the full-speed time, and (C) the decelerating time. In this instance, the accelerating time of the instrument is approximately 0.14 second, the full speed time is 0.8 of a second and the decelerating time is 0.06 second. These are nominal values as the balancing time is dependent upon the following factors:

1. Percent of span represented by the input signal.
2. Amount of damping.
3. Value of the a.c. line voltage. (Nominal values are for 115V a.c. line voltage.)

D. FREQUENCY RESPONSE

Recording instruments operating on the servo-balancing principle are designed for applications involving relatively slow changes in d.c. signal levels. When changes of a rapid nature are to be monitored, the frequency response characteristic of the instrument may become an important consideration.

Recorder frequency response varies with the peak-to-peak amplitude of the input signal. The curve in Figure 17 shows maximum sinusoidal signal frequencies which can be reproduced versus peak-to-peak signal amplitude in percent of span.

The curve applies to both the 1 and the 2-1/2 second balancing time instruments by reading the appropriate values on the frequency ordinate.

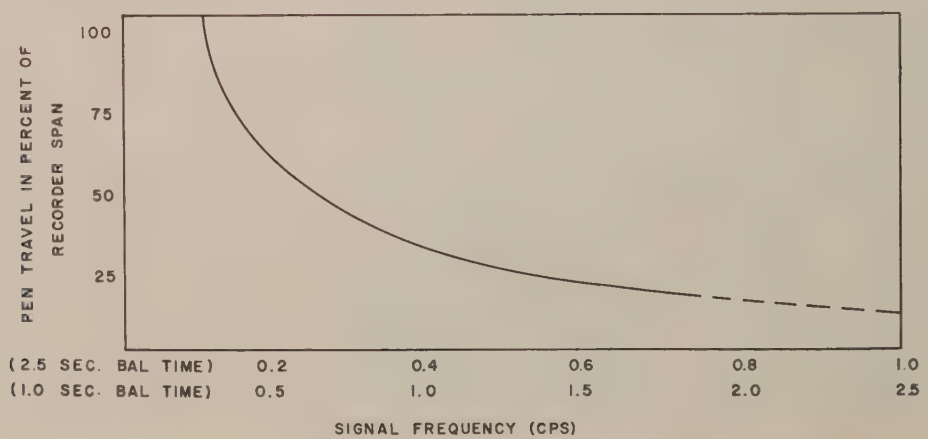


Figure 17. Frequency Response

A. WARRANTY

Varian Associates warrants the recorder products manufactured by the Instrument Division to be free from defects in material and workmanship. Varian's liability under this warranty is limited to servicing or adjusting any instrument returned to the factory or to a designated service shop for that purpose, and to replacing any defective parts thereof (except listed items specifically exempted from the warranty in writing). This warranty is effective for one year after delivery of the recorder product to the original purchaser when (a) the recorder product is returned to the factory or to the designated service shop, transportation charges prepaid, and when (b) the recorder product is disclosed to Varian's (or the designated local representatives) satisfaction to be defective, through no fault of the user. If the malfunction has been caused by misuse or abnormal conditions of operation, repairs will be billed to the instrument owner. In this case, an estimate will be submitted before the work is started.

WARRANTY EXCEPTION LIST FOR RECORDER PRODUCTS

(a) Tubes . . . . . .3 months
(b) Slidewire . . . . .1 million operations or one year
(c) Sealed Chopper . .1000 hours or one year
(d) Pen Cord . . . . .No warranty

B. FIELD AND FACTORY SERVICE

Field and factory service shops are maintained for your convenience. (See the list of the firms and their locations below.)

In the event an instrument requires servicing please make contact with the nearest representative or the factory. If the instrument is to be returned to the factory, shipping instructions may be obtained by writing to the Service Manager, Instrument Division, Varian Associates, 611 Hansen Way, Palo Alto, California. Please include instrument serial numbers, a complete description of the malfunction and any other pertinent information.

The Instrument Division has established the policy that every instrument returned for service will be completely checked in addition to correcting the cause of the malfunction. Each instrument shipped from the Service Department will be in "new instrument condition"; that is, each instrument will meet the specifications under which it was originally sold. When it appears that it will be unusually expensive to bring an instrument up to specification, the Service Department will make contact with the owner for instructions.

If an instrument becomes defective during the first two weeks, the Warranty will be extended to cover all shipping costs.

NEW ENGLAND STATES & EASTERN NEW YORK
YEWELL ASSOCIATES, INC.
• WALTHAM, MASS., 751 Main Street, TWinbrook 3-7420
• BRIDGEPORT, CONN., 1101 E. Main Street, FOrest 6-3456

NORTHERN & WESTERN NEW YORK
J. D. RYERSON ASSOCIATES, INC.
• SYRACUSE 2, NEW YORK, 412 E. Genesee Street, 76-8344

NEW YORK CITY & NORTHERN NEW JERSEY
RMC ASSOCIATES
• NEW YORK, NEW YORK, 236 East 75th Street, TRafalgar 9-2023
• BOGOTA, NEW JERSEY, 114 E. Main Street, Diamond 2-5343

EASTERN PENNSYLVANIA & SOUTHERN NEW JERSEY
I. E. ROBINSON COMPANY
• UPPER DARBY, PA., 7404 W. Chester Pike, FLanders 2-7017
• CAMP HILL, PA., 2120 Market Street, REgent 7-5541
• ASBURY PARK, N. J., 702 Mattison Avenue, PRospect 4-1890

EASTERN OHIO & WESTERN PENNSYLVANIA
M. P. ODELL COMPANY
• WESTLAKE, OHIO, 26614 Center Ridge Road, TRinity 1-8000
• PITTSBURGH 21, PA., 750 Penn Avenue, FRemont 1-1231

DELAWARE, MARYLAND & WASHINGTON, D. C.
HORMAN ASSOCIATES, INC.
• WASHINGTON, D. C., 2017 S Street, N. W., DEcatur 2-5705
• BALTIMORE 10, MARYLAND, 635 St. John's Rd., HOpkins 7-2290

SOUTHEASTERN STATES
BIVINS & CALDWELL, INC.
• HIGH POINT, NORTH CAROLINA, Security Bank Bldg., 3672
• ATLANTA 5, GA., 3133 Maple Drive, N. E., CHerokee 7522

FLORIDA
ARTHUR H. LYNCH & ASSOCIATES
• FORT MYERS, FLORIDA, P. O. Box 466, Edison 4-4431

MICHIGAN & TOLEDO, OHIO
S. STERLING COMPANY
• DETROIT 35, MICH., 15310 W. McNichols Rd., Broadway 3-2900

NORTH CENTRAL STATES
ALFRED CROSSLEY ASSOCIATES, INC.
• CHICAGO 40, ILL., 4501 N. Ravenswood Avenue, UPtown 8-1141
• DAYTON 9, OHIO, 53 Park Avenue, OXmoor 3594
• ST. PAUL 14, MINN., 842 Raymond Ave., MIdway 5-4955

KANSAS, MISSOURI & SOUTHERN ILLINOIS
HARRIS-HANSON COMPANY
• ST. LOUIS 17, MO., 2814 So. Brentwood Blvd., Mission 7-4350
• KANSAS CITY 30, MISSOURI, 7916 Paseo Avenue, Highland 4-6744

SOUTH CENTRAL STATES
EARL LIPSCOMB ASSOCIATES
• DALLAS 9, TEXAS, Box 7084, ELmhurst 5345
• HOUSTON 5, TEXAS, P. O. Box 6573, JAckson 4-9303

CALIFORNIA & SOUTHWESTERN STATES
NEELY ENTERPRISES
• NO. HOLLYWOOD, CALIF., 3939 Lankershim Blvd., STanley 7-0721
• SACRAMENTO 14, CALIF., 1317-15th Street, GIlbert 2-8901
• SAN CARLOS, CALIF., 501 Laurel Street, LYtell 1-2626
• SAN DIEGO, CALIF., 1055 Shafter Street, ACademy 3-8106
• ALBUQUERQUE, N. M., 107 Washington Street, S. E., 5-5586
• LAS CRUCES, N.M., 126 Water Street, JAckson 6-2486
• PHOENIX, ARIZONA, 641 E. Missouri Avenue, CRestwood 4-5431

NORTH WESTERN STATES
RON MERRITT COMPANY
• SEATTLE 99, WASH., 120 W. Thomas Street, GArfield 6644
• PORTLAND 9, ORE., 1238 N. W. Glison, CApitol 7-1281

CANADA
VARIAN ASSOCIATES OF CANADA, LTD.
• GEORGETOWN, ONTARIO, 45 River Drive, Triangle 7-3664

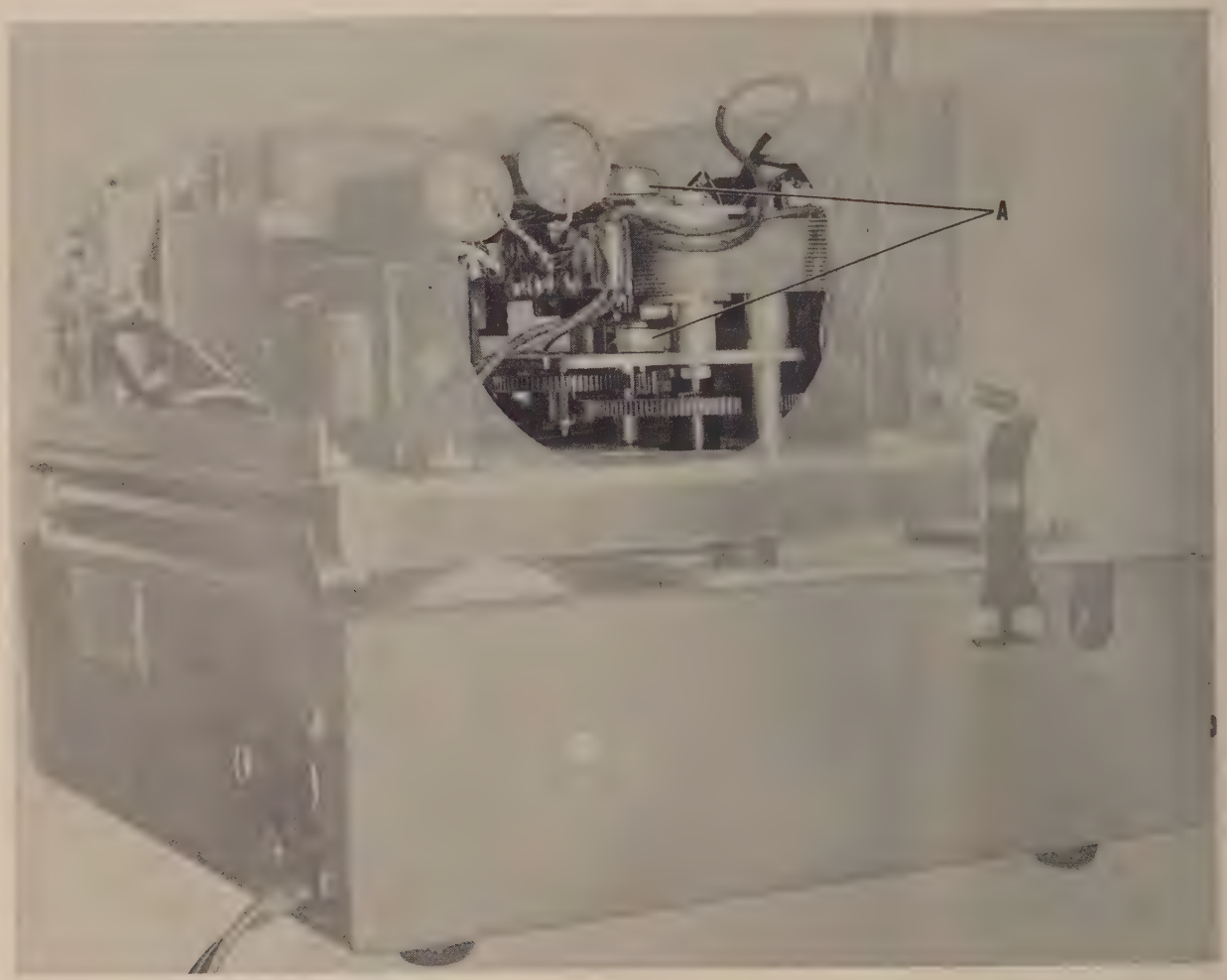


Figure 18. Lubrication Points

C. PREVENTATIVE MAINTENANCE

1. Reference Cell

The 1.34 volt mercury reference cell has a normal life in this application of from 3 to 4 months and therefore should be replaced at not more than 3 month intervals. If the cell has been in use for a period of time approaching three months and a critical recording is to be made, it is advisable to replace the cell before making the recording to prevent malfunction during the recording. When in use, the cell will discharge at a rate of from one to two percent per month until it is exhausted at which time the voltage will suddenly drop to an unusable value.

Replacements are available from Varian Recorder Representatives, the Instrument Division of Varian Associates and will generally be available locally at radio supply houses. A small supply may be kept on hand as normal shelf life is stated by the manufacturer to be one year.

2. Lubrication

At the same time the reference cell is being replaced (3 month intervals) the balancing-motor bearings (A in Figure 18) should be lubricated. A drop of mineral oil on each bearing is sufficient.

Every six months the pen drive-cable idler pulleys (A of Figure 19) should be lubricated with a small amount of machine oil.

Also, the chart drive shaft gears (E of Figure 8B) should be checked for cleanliness and, if necessary, a small amount of LUBRIPLATE (Type 105) applied.

DO NOT lubricate pen carriage rod (B of Figure 19) inasmuch as the pen carriage bearing is of the porous, self-lubricating type and additional lubrication may be a hindrance rather than a help. Wipe the pen carriage rod with a clean, dry cloth only.

3. Pen Care and Cleaning

The recorder pen will function best when it is kept clean and free flowing. Plain water is sufficient to clean most inks from the pen and other metal parts. Water may be forced through the reservoir, channel and pen point by filling the reservoir with water, covering the top hole of the pen with one thumb and exerting pressure on the top of the reservoir with the other thumb. If the pen is clean, a stream of clear water will be forced out of the point.

If the pen is plugged it may be necessary to use the pen cleaner (3 of Figure 1). Run the

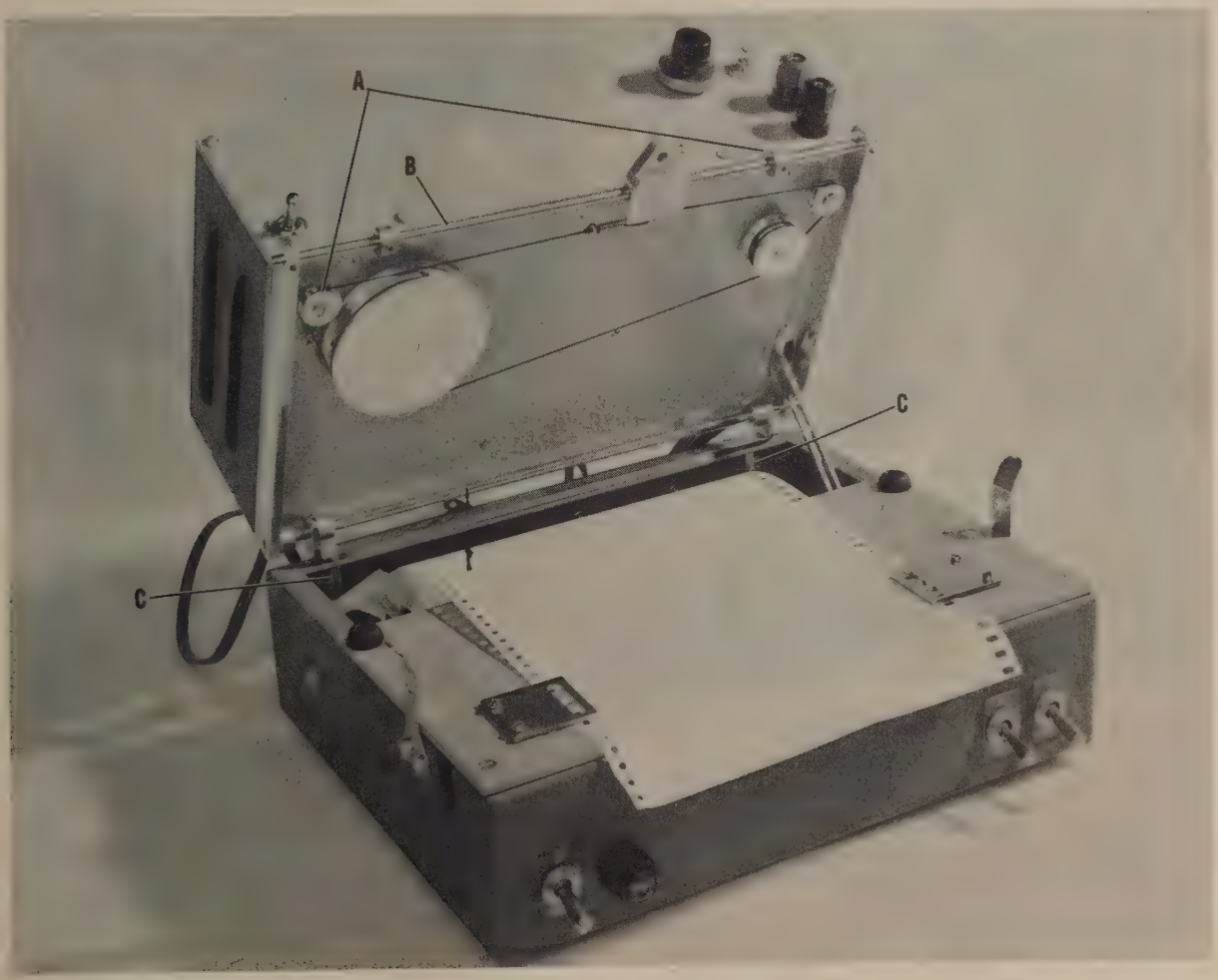


Figure 19. Lubrication Points

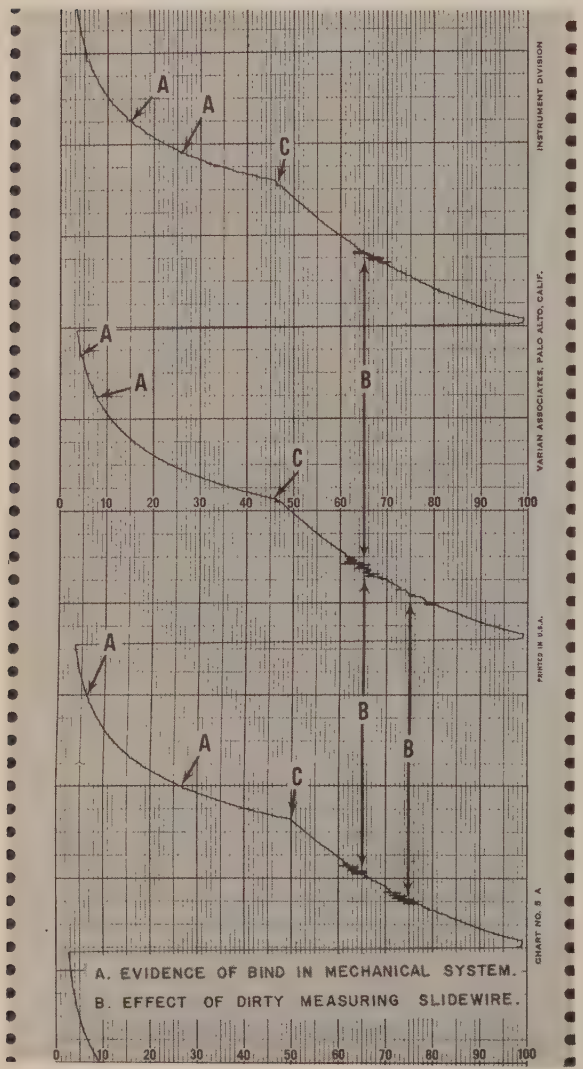


Figure 20. Record of Capacitor Discharge Curves (RC Changed at Points C)

pen cleaner in and out of the pen from the top, at the same time flushing with water. Pens that are excessively dirty may need to be soaked in hot soapy water, alcohol, or one of the commercial pen cleaning fluids.

When there are to be long intervals of time between recordings it is best to clean the pen immediately following a recording. Avoid allowing inks to dry in the pen. The plastic reservoir cap should be kept in place at all times to minimize ink drying. Keep all metal parts of the recorder free from ink as recorder inks can be corrosive.

D. TESTING

General

Test the recorder performance by following the instructions found in the Performance Check section, page 7.

Symptoms and remedies of possible malfunctions are found on page 21.

E. SPECIFIC PROCEDURES

1. Replacing Mercury Reference Cell

(a) Unplug line cord from a.c. outlet.

(b) Remove servo cover (see page 26 for instructions).

(c) Locate mercury reference cell (A of Figure 21A) on top right side of unit. Hook the cell retaining spring (B) on one side of the battery clip (C) and remove the cell by placing screw driver blade behind the cell and prying out.

(d) Place new cell in the holder. Positive terminal (flat side) goes to the bottom of the holder.

(e) Replace cell-retaining spring and servo cover.

2. Chopper Cleaning and Adjustment

(a) Unplug line cord from a.c. outlet.

(b) Remove servo cover (instructions on page 26). Locate and remove chopper dust cover (D of Figure 21B).

(c) Plug in the line cord. Line voltage must be within the limits specified on the data sheet, facing page 2 and preferably at the mid-value.

(d) Locate outer chopper contacts (E of Figure 21A, movable, and F of 21A, stationary). Clean by inserting a clean piece of bond paper between the chopper contacts and rubbing the contacts a few times. The inner contacts are not used.

(e) Short-circuit the input terminals and set the pen against the left-hand stop by rotating the ZERO ADJ. control to the full CCW position.

(f) Turn off the SERVO switch and rotate the ZERO ADJ. control to the full CW position.

TABLE OF SYMPTOMS AND REMEDIES

Symptom	Possible Cause	Remedy
A. Pen will not overshoot with DAMPING control in full clockwise position. (Input short-circuited.)	1. Defective tube. 2. Poor chopper action. 3. Defective capacitor C110, 112, 113, 114, 115, or 116.	1. Replace tube. 2. Clean chopper contacts. Adjust if necessary. 3. Replace capacitor.
B. Non-uniform pen speed through full range of travel.	1. Dirty chopper contacts. 2. Pen carriage binding on shaft. (See A of Fig. 20, page 20.) 3. Drive cable tension insufficient. 4. Bind in mechanical system. (See A of Fig. 20, page 20.)	1. Clean chopper contacts. Adjust if necessary. 2. Clean shaft. 3. Adjust tension. 4. Eliminate bind by cleaning, adjusting and lubricating.
C. Pen travels faster in one direction than in other.	1. Balancing signal has non-symmetrical waveform due to poor chopper contact adjustment. 2. Drive cable tension insufficient.	1. Adjust chopper contacts. 2. Adjust tension.
D. Poor sensitivity, large dead zone.		
1. Servo motor sheave does not feel "tight".	1a. Stray a.c. pick-up. b. Low amplifier gain. c. Excessive source resistance.	1a. Check grounding for a.c. on input signal. b. Check tubes for gain and noise. c. Insure source resistance is within maximum permissible value specified on data sheet.
2. Servo motor feels "tight".	2a. Bind in mechanical system (See A of Fig. 20, page 20.) b. Excessive drive cable tension.	2a. Eliminate bind on pen-carriage, idler sheaves or measuring slidewire shaft. b. Adjust tension.
E. Instrument cannot be calibrated by use of the CALIBRATION control.	1. Low voltage from reference cell.	1. Replace reference cell.
F. Pen moves to extreme position of pen travel and stays there.	1. Open circuit in input system. 2. Reference cell not in place. 3. Extremely low reference cell voltage. 4. Chopper malfunction.	1. Check external connections. 2. Check connections to cell. 3. Replace reference cell. 4. Clean and adjust chopper.
G. Pen hunts at any position of DAMPING control.	1. Excessive amplifier gain. 2. Loose motor or slidewire sheave.	1. Reduce line voltage to 110-120 volts, or replace amplifier input tube with one having less gain. 2. Tighten sheaves.
H. Repeated pen "jitter" at same point on chart. (See B of Fig. 20, page 20).	1. Dirty measuring slidewire.	1. Clean measuring slidewire per page 23.

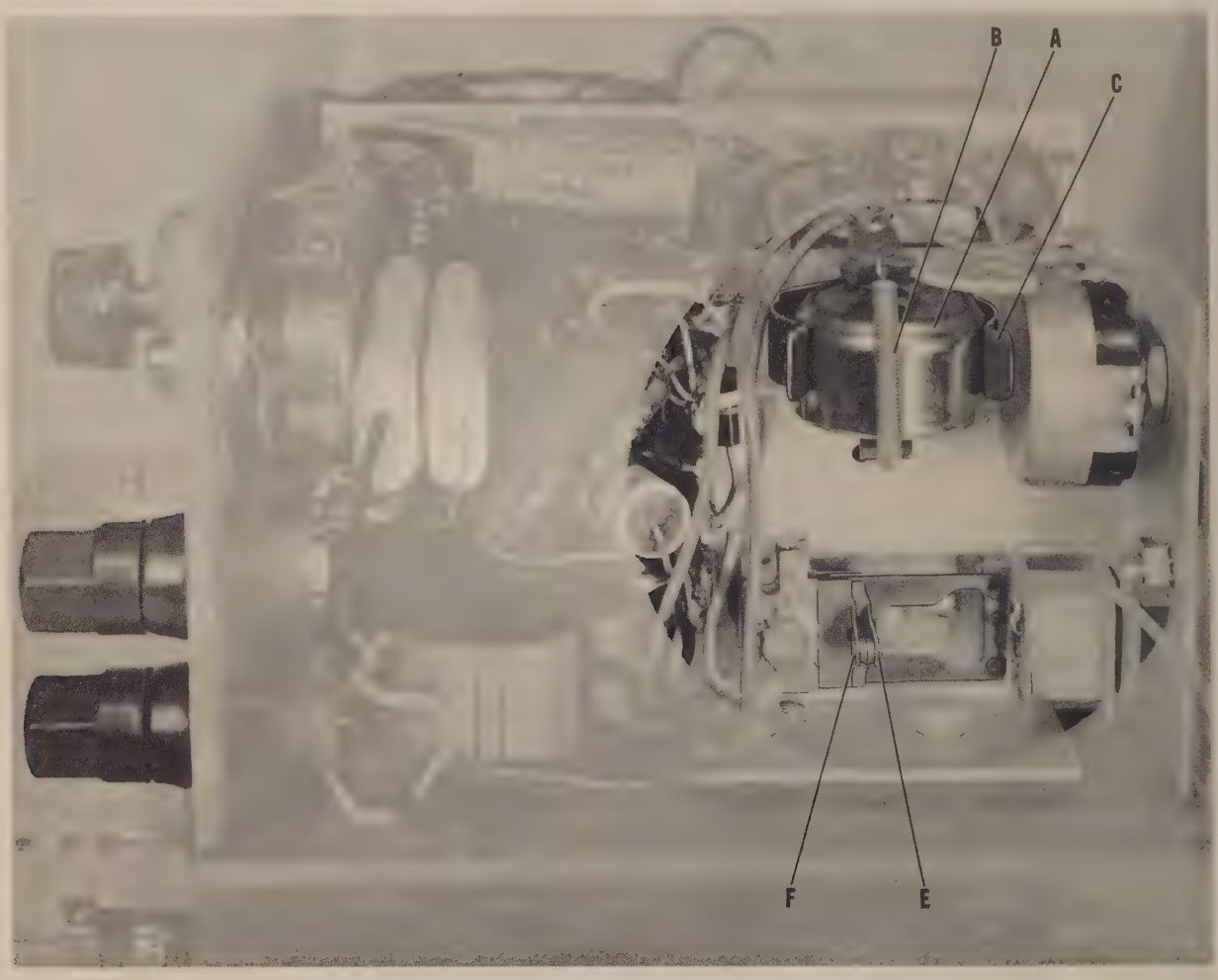


Figure 21A. Replacing Mercury Reference Cell

(g) Connect an oscilloscope between the stationary chopper contact and the chopper chassis ground (see Figure 22). Adjust the oscilloscope for a presentation of two or three cycles of the square-wave signal.

(h) If contacts are clean, waveform will appear as at A and B, Figure 23; if dirty as at C and D of 23.

(i) If the square-wave is not symmetrical (see Figure 23B), carefully bend the stationary contact (using a relay bending tool, soldering aid or the like) until a symmetrical waveform is obtained.

(j) Remove leads from the chopper and unplug the recorder line cord.

k. Replace chopper and servo covers.

3. Tube Replacement

(a) Unplug the line cord from the a.c. circuit.

(b) Remove servo cover (page 26).

(c) Remove the two lower screws on the servo unit front panel, allowing the front panel to tilt forward as shown in Figure 24.

(d) Tubes are now accessible for replacement. See Figure 24 for the tube locations.

(e) Replace front panel and servo cover.

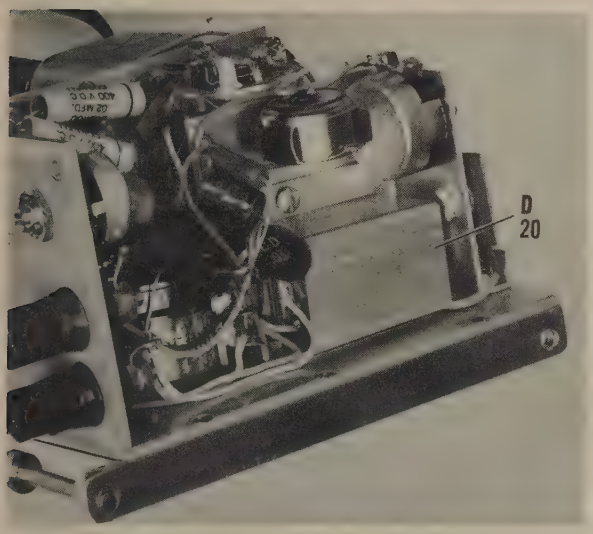


Figure 21B. Chopper Cleaning

4. Cleaning the Measuring Slidewire

(a) Disconnect instrument from power line, remove servo cover, and drop front panel forward (as shown in Figure 24) by removing 2 screws on lower front of panel.

(b) Locate the measuring slidewire (A of Figure 24). The slidewire cap is held in place either with 2 machine screws or 3 drive pins. If pins are used, cement covering pins must be scraped away with a sharp knife. The pins may then be extracted by inserting a sharp knife blade under the pin heads and prying out.

(c) Disassemble and clean slidewire as follows:

(1) Remove slidewire cap and lift slidewire wiper-arm contact-spring out of the top of the top of the slidewire case.

(2) Using lint-free material, clean slidewire case and cap, slidewire wiper-arm contact-spring, and slidewire. To clean slidewire, use a toothpick, wooden match or the like to insert cleaning material between slidewire and center post. Rotate cleaning material around center post while turning slidewire wiper arm at the sheave.

CAUTION

Do not scratch or otherwise mar the slidewire.
Do not use solvents for cleaning.
Do not remove wiper arm of slidewire.

(3) Apply a quantity of LUBRIPLATE (Type 105) to slidewire and wiper-arm contact spring.

(d) Reassemble slidewire and servo unit in reverse to above.

5. Replacing Pen Drive Cable (See NOTE for reversed polarity instruments.)

(a) Place the pen carriage against the left collar stop, remove the pen and tilt servo unit back.

(b) Loosen the lug screw on the back of the pen carriage and remove all old cable from the pen carriage, sheaves and tension spring.

Figure 22. Chopper Adjustment

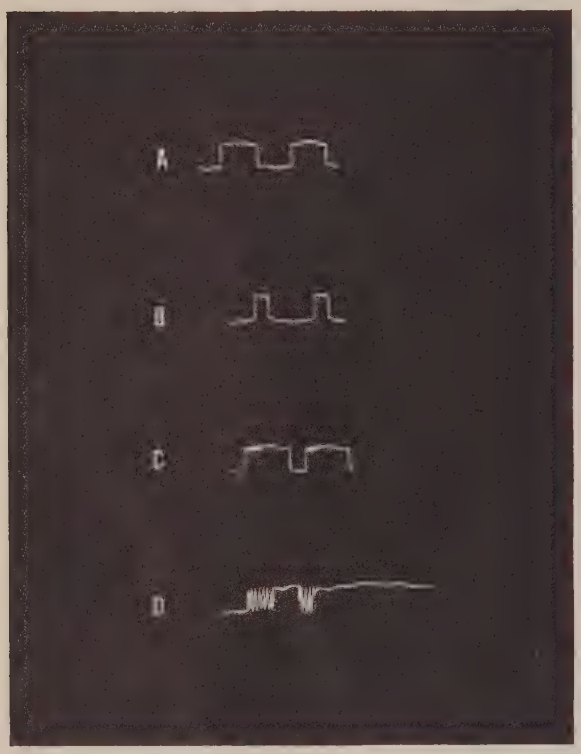


Figure 23. Chopper Waveforms

(c) Remove slidewire sheave using an Allen wrench for a 4-40 set screw.

(d) Cut approximately six feet (1.8 meters) of new cable (Varian Part #4230100005 or General Cement catalog #75-1000, available at radio supply houses) and insert both ends (one at a time) through the hole on the top of the slidewire sheave. (Inspect sheave carefully for any sharp edges which might cut cable.) Draw ends out through the set-screw hole such that the loop thus formed catches under the rivet head on the top of the sheave. The two ends of the cable now extending from the set-screw hole should be nearly equal in length.

(e) Rotate the slidewire shaft to the full CCW position and replace the sheave on the shaft with the rivet-head side next to the bottom of the servo unit and the set-screw hole facing the rear of the servo unit. The end of the slidewire shaft should be flush with the underside of the sheave. Tighten the set screw.

REFER TO FIGURE 25 WHEN PERFORMING THE FOLLOWING STEPS:

(f) Rotate the slidewire sheave approximately 1/4 turn CW and bring one end of the cable around the back (CCW) of the sheave and over the right-hand idler pulley.

(g) Bring the end of the cable over to the pen carriage, take up the slack and make a CCW loop around the screw and lug on the pen carriage. Temporarily tighten the screw.

(h) Take the other end of the cable (at the measuring slidewire sheave) and make three CW turns around the sheave, progressing away from the bottom of the servo unit. Use cellophane tape to prevent the loops unwinding from the sheave.

(i) Bring the end of the cable over to the balancing motor sheave, take up the slack and make three CW turns around the sheave, progressing towards the bottom of the servo unit so that the last loop is closest to the servo unit. (Temporarily tape these loops to the sheave.)

(j) Bring the free end of the cable around the left-hand idler pulley, take up the slack and fasten to the end of the tension spring using a firm non-slip knot (the other end of the tension spring is hooked through the hole in the lug on the pen carriage).

(k) Clip off the excess cable at the knot.

(l) Remove the tape from the sheaves and loosen the lug screw on the pen carriage. Draw the cable around the screw so that the tension on the cable expands the tension spring approximately 1/32" (1 mm). Tighten the screw, making certain that the lug is extended parallel to the pen carriage support rod.

(m) Clip off excess cable at the lug, leaving about one inch (25 mm) of free cable. Tuck this free end into the center of the tension spring.

NOTE

Directions for cable replacement on reversed polarity input instruments are the same as above with the following exceptions:

(1) In part (a), the pen carriage should be placed against the right-hand collar stop.

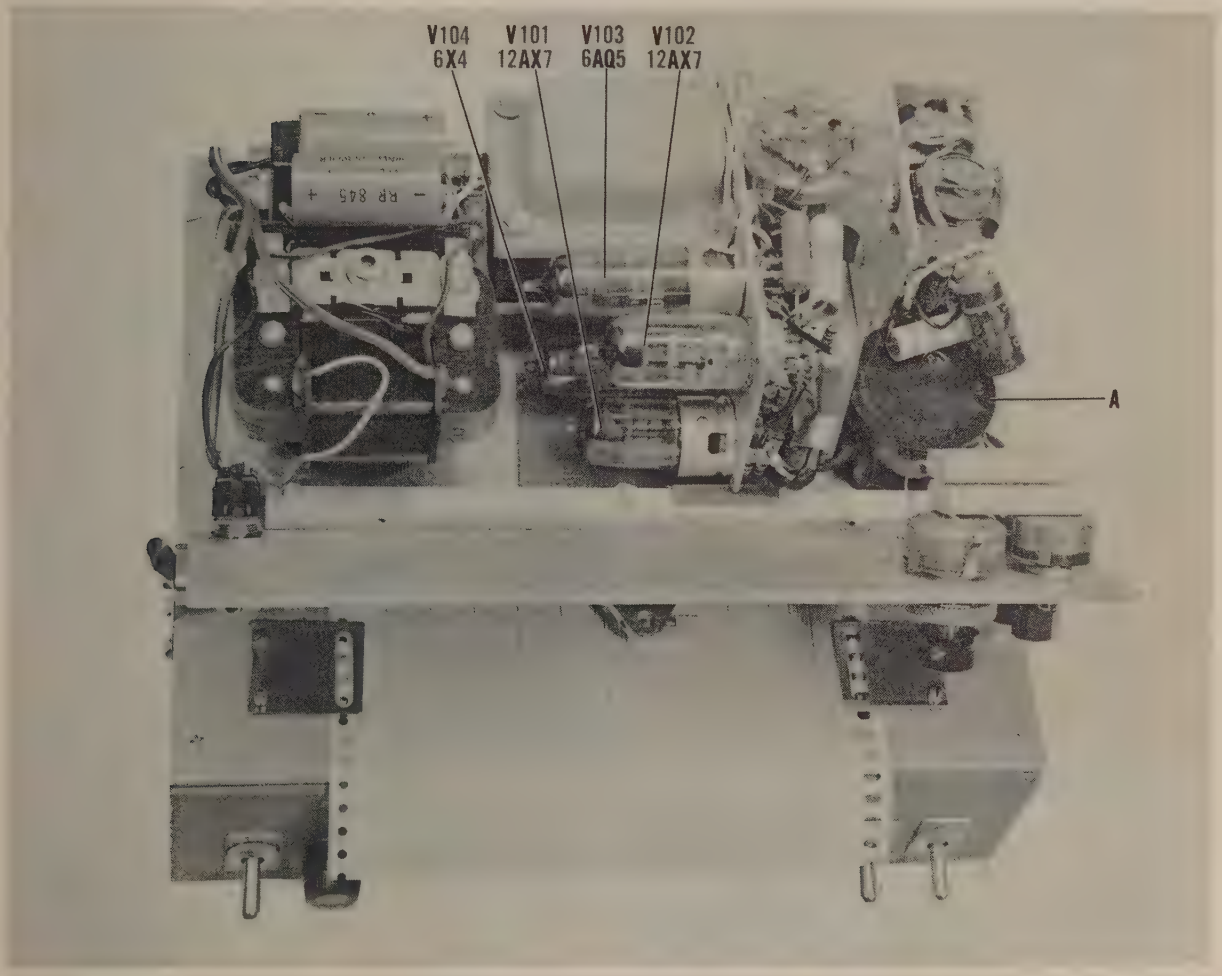


Figure 24. Tube Replacement

(2) In part e., the slidewire shaft should be rotated to the full CW position.

(3) In part f., the slidewire sheave rotation should be 1/4 turn in the CCW direction.

6. Chart Roll Holder Alignment

The chart roll holder must be positioned, with respect to the chart drive sprockets, so that the chart feeds across the chart-drive plate without wrinkling or buckling. If buckling or wrinkling of the chart paper occurs, make the following adjustment:

(a) Remove chart paper and locate the two screws securing the chart roll holder to the bottom of the chart drive unit cabinet. (L of Figure 8A, page 8.) Loosen the screws about 1/4 turn. Do not remove the screws.

(b) Install chart paper. Turn on POWER and CHART switches (a fast chart speed is desirable).

(c) Move chart roll holder until paper is feeding properly.

(d) Holding chart roll holder firmly in place, tighten the two screws securing the chart roll holder to the bottom of the chart drive cabinet.

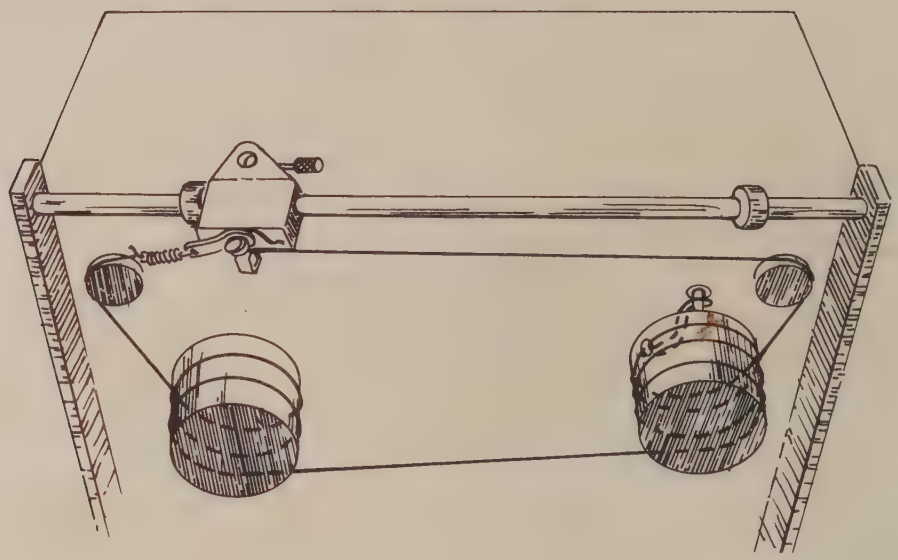


Figure 25. Replacing Pen Drive Cable

(e) Recheck paper feed alignment.

7. Servo Unit Alignment

The servo unit must be aligned with respect to the chart paper so that the pen travel is parallel to the lines across chart. To check alignment, proceed as follows:

(a) Turn on POWER and SERVO switches. (CHART switch(es) turned off. Chart and pen installed.)

(b) Short-circuit INPUT terminals and rotate ZERO ADJ. control to obtain full-span pen travel. The resulting trace should be parallel to the chart divisions extending across the chart.

(c) If the servo unit is out of alignment, remove the pen and tilt the servo unit to the rear. Locate the two screws holding the servo unit hinge bracket to the chart drive unit. (See C of Figure 19.)

(d) Using a 1/4" (6.4 mm) open end wrench, loosen the hex nuts into which the two screws are threaded.

(e) Put servo unit down in position, install pen and rotate ZERO ADJ. control to check alignment. Reposition servo unit until proper pen travel is obtained.

(f) Carefully tighten hex nuts and recheck alignment.

F. ACCESS TO COMPONENTS

1. Removing Servo Cover (See Figure 26)

(a) Unplug the servo unit power cord from the chart drive unit.

(b) Unscrew the two screws at the two top corners of the servo unit front panel. Unscrew the two screws at bottom rear of the servo unit.

(c) Remove cover by raising the front of the cover so that the lip on the top front clears the zero adjust and damping potentiometers. Withdraw to the rear using care not to disturb power cord connections on the left side.

(d) Replace in the reverse order to above.

NOTE

If there are two short screws and two long screws, use short screws in the rear of the cabinet.

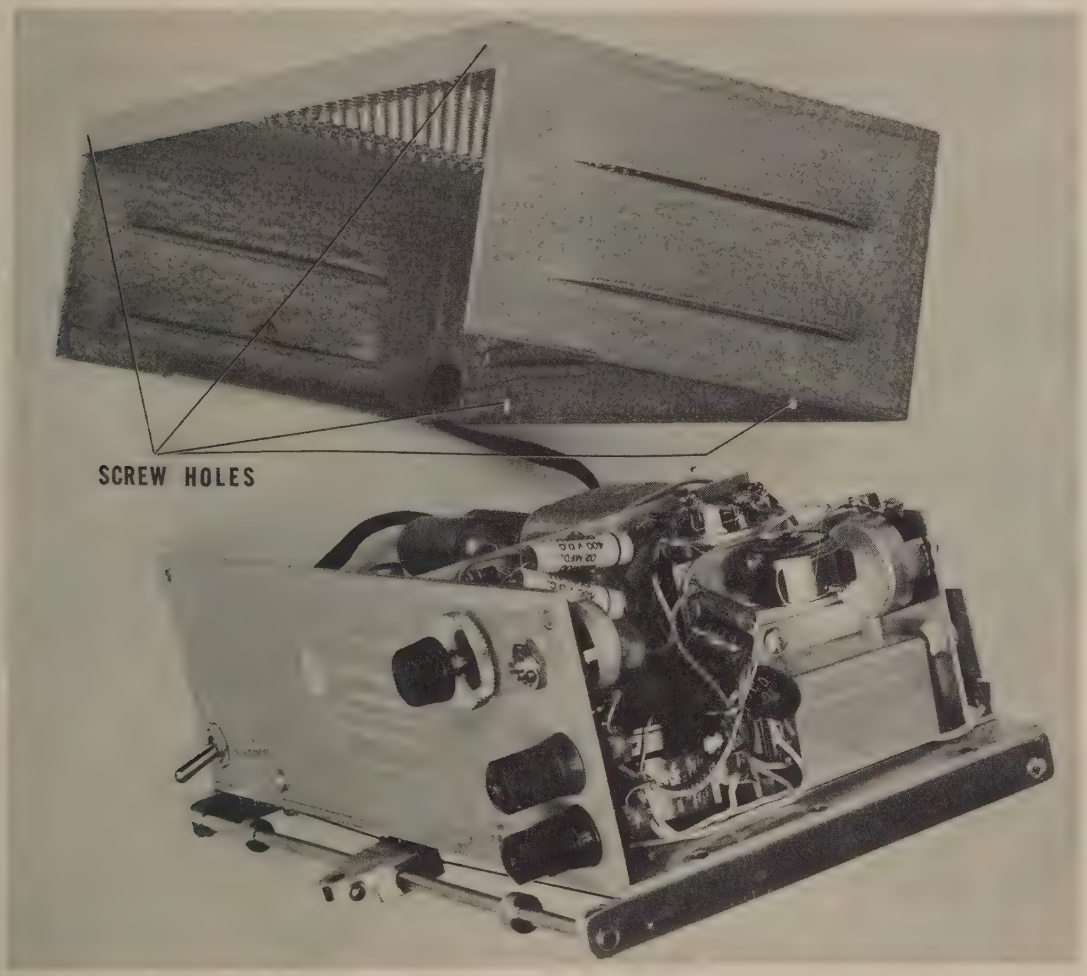


Figure 26. Removing Servo Cover

2. Separating Servo Unit from Chart Drive Unit

(a) Unplug servo unit power cord from chart drive chassis.

(b) Loosen set screws of 2 collars at outermost ends of hinge rod (see Figure 27). Slide collars inward.

(c) Tilt servo unit up and slide to the left (facing front of instrument) until the left side rail is free of hinge rod. Disengage servo stay from end of stud located in chart drive unit.

(d) Raise left end of servo slightly so that left side rail clears rod and slide the servo to the right until the right side rail slips free.

(e) Replace in reverse order to above. Make certain the collars are replaced tightly to prevent lateral movement of the servo unit.

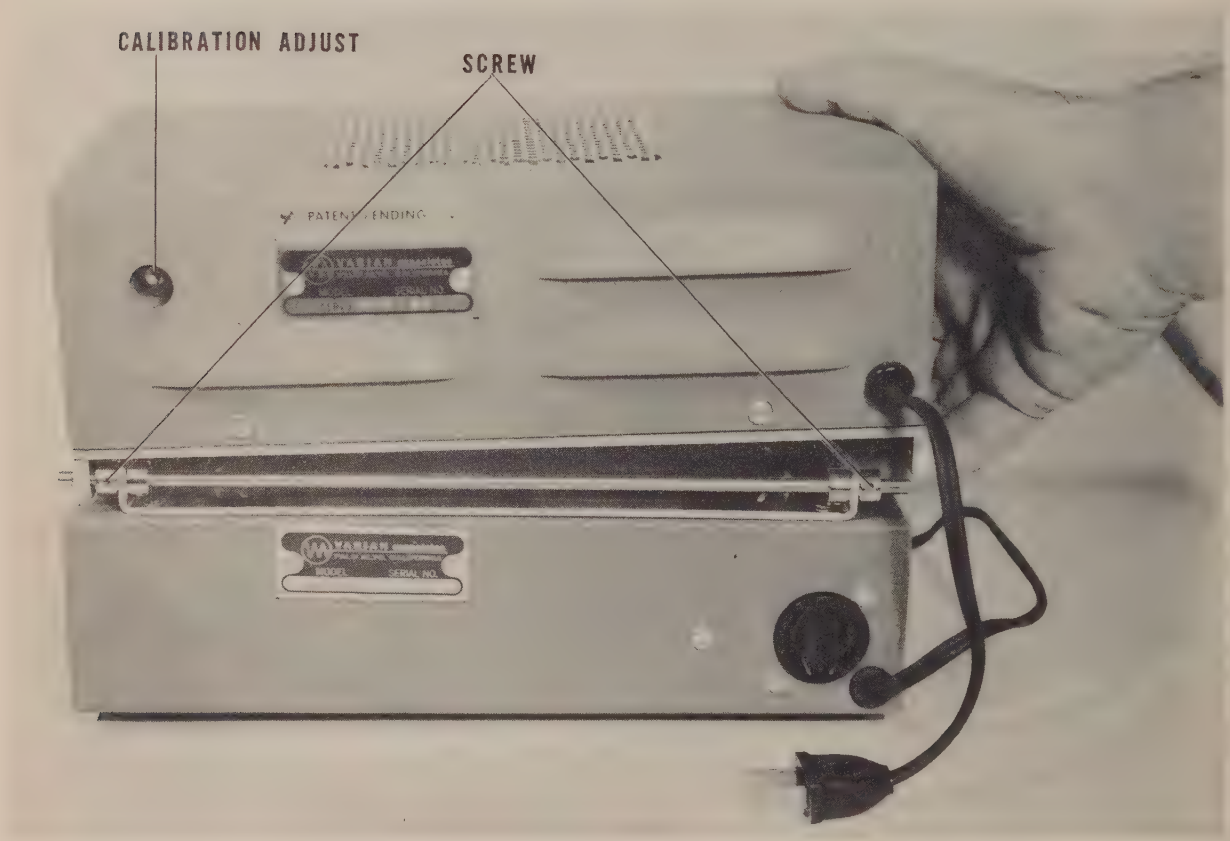


Figure 27. Separating Servo Unit from Chart Drive Unit

MECHANICAL PARTS LIST (G-10)

Symbol No.*	Part No.	Description
*Parts are called out by symbol number on Figures 28, 29, and 30.		
SERVO UNIT		
1	4400300001	Zero Adjust Knob
2	4350602002	Zero Adjust Lock
3	900671	Pen Carriage
4	900757	Knurled Screw
5	900639	Pen Carriage Rod
6	900752-1	Pen Carriage Rod Collar
7	901350	Drive Cable Anchor
8	4351101001	Drive Cable Tension Spring
9	4230100005	Drive Cable, 72 in. long (1.8 meters)
10	901028 901027	Idler Pulley Shoulder Screw (for Idler Pulley)
11	900640 900641	Motor Sheave (1 sec. Bal. Time) Motor Sheave (2-1/2 sec. Bal. Time)
12	900638	Slidewire Sheave
13	901000	Servo Hinge Pin
14	900642	Servo Hinge Bracket
15	900752-1	Servo Hinge Collar
16	900760	Servo Stay
17	940182	Front Panel, 3 in. high (7.62 mm) Front Panel, 3-1/8 in. high (7.94 mm)
18	900759 901423-1 901423-2	Servo Cover (for 3 in. Panel) Servo Cover (for 3-1/8 in. panel, 50 cps) Servo Cover (for 3-1/8 in. panel, 60 cps)
19	900645	Balancing Motor Shaft
20 (Fig. 21B, page 23)	901342	Chopper Dust Cover
None	900867	Plastic Reservoir Cap (on Pen Reservoir)

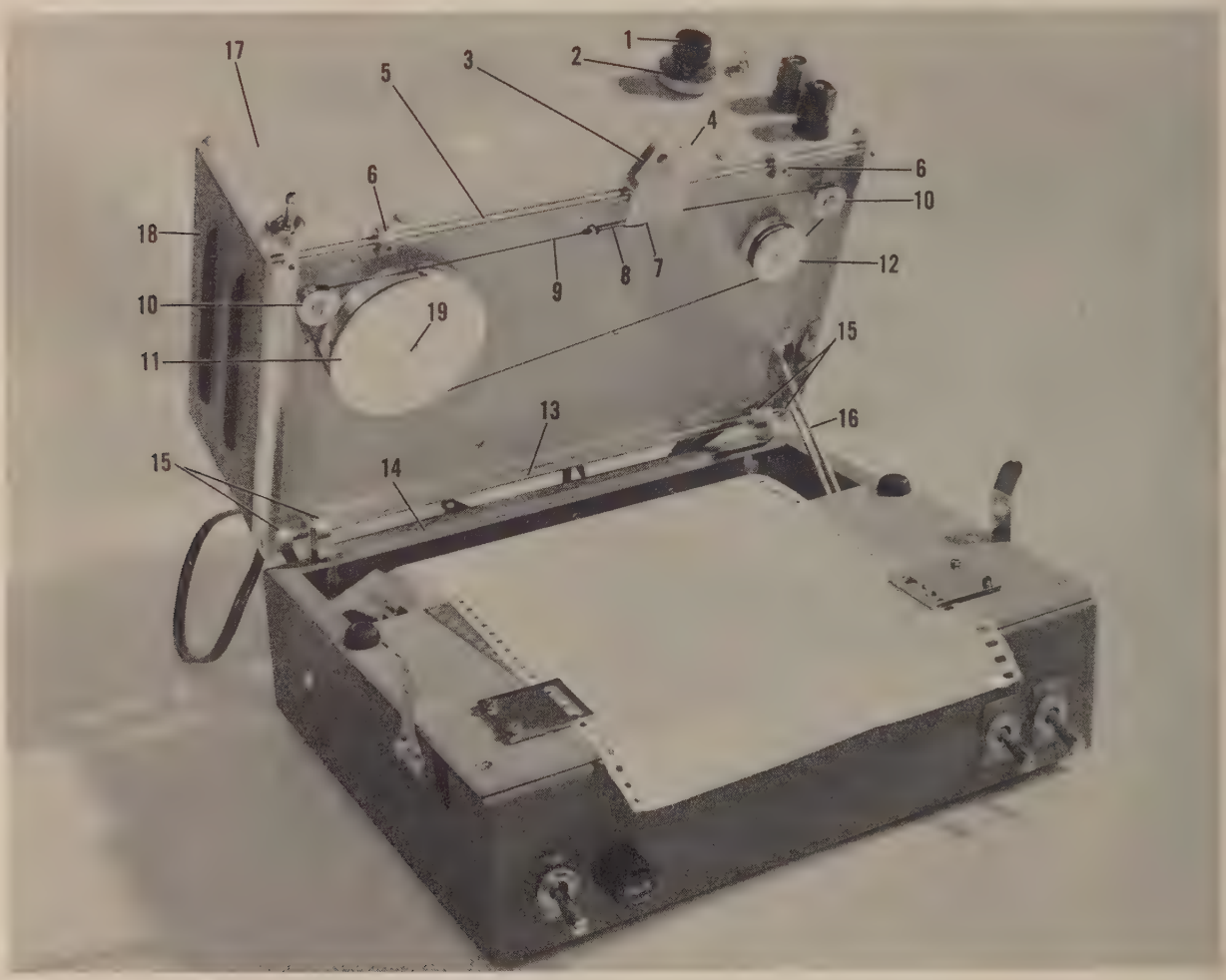


Figure 28. Servo Unit Mechanical Parts

MECHANICAL PARTS LIST (G-10) (Cont)

Symbol No.*	Part No.	Description
	*Parts are called out by symbol number on Figures 28, 29, and 30.	
CHART DRIVE UNIT		
21	4350704002	Servo Unit Bumper
22	940181	Chart Drive Plate
23	900651	Chart Hold-Down
24	900672	Sprocket
25	4351902010	Mach. Screw 6-32 x 1/4, Phil. Flt. Hd, Cad. Pltd.
26	4351902011	Mach. Screw, 6-32 x 5/16 (1 speed only, for 2 speeds see symbol 25), Phil. Flt Hd., Cad. Pltd.
27	900678-1	Power Switch Nameplate
28	900678-4	Chart Lo Switch Nameplate (Serial Nos. 1 thru 1050)
29	900678-3	Chart Hi-Lo Switch Nameplate (Serial Nos. 1051 and above)
	900678-3 (Obs.)	Chart Hi Switch Nameplate (Serial Nos. 1 thru 1050)
30	900731	Chart Spindle Bracket
31	900729	Chart Spindle
32	901001	Servo Support Clip
33	901002	Servo Support Clip Plate
34	960126	Chart Drive Chassis
35	900653	Torsion Spring
36	900752-2	Collar
37	900751	Spring
38	4240103001	Coupling
39	900666-3	Gear (2 speed only)
	900666-1	Gear (1 speed only)
40	900636	Chart Motor Bracket
41	900649-3	Chart Drive Shaft
42	900666-2	Gear
43	900646	Pillow Block Support
44	900753	Pillow Block
45	4351902012	Mach Screw, 6-32 x 3/8, Phil. Flt. Hd., Cad. Pltd.

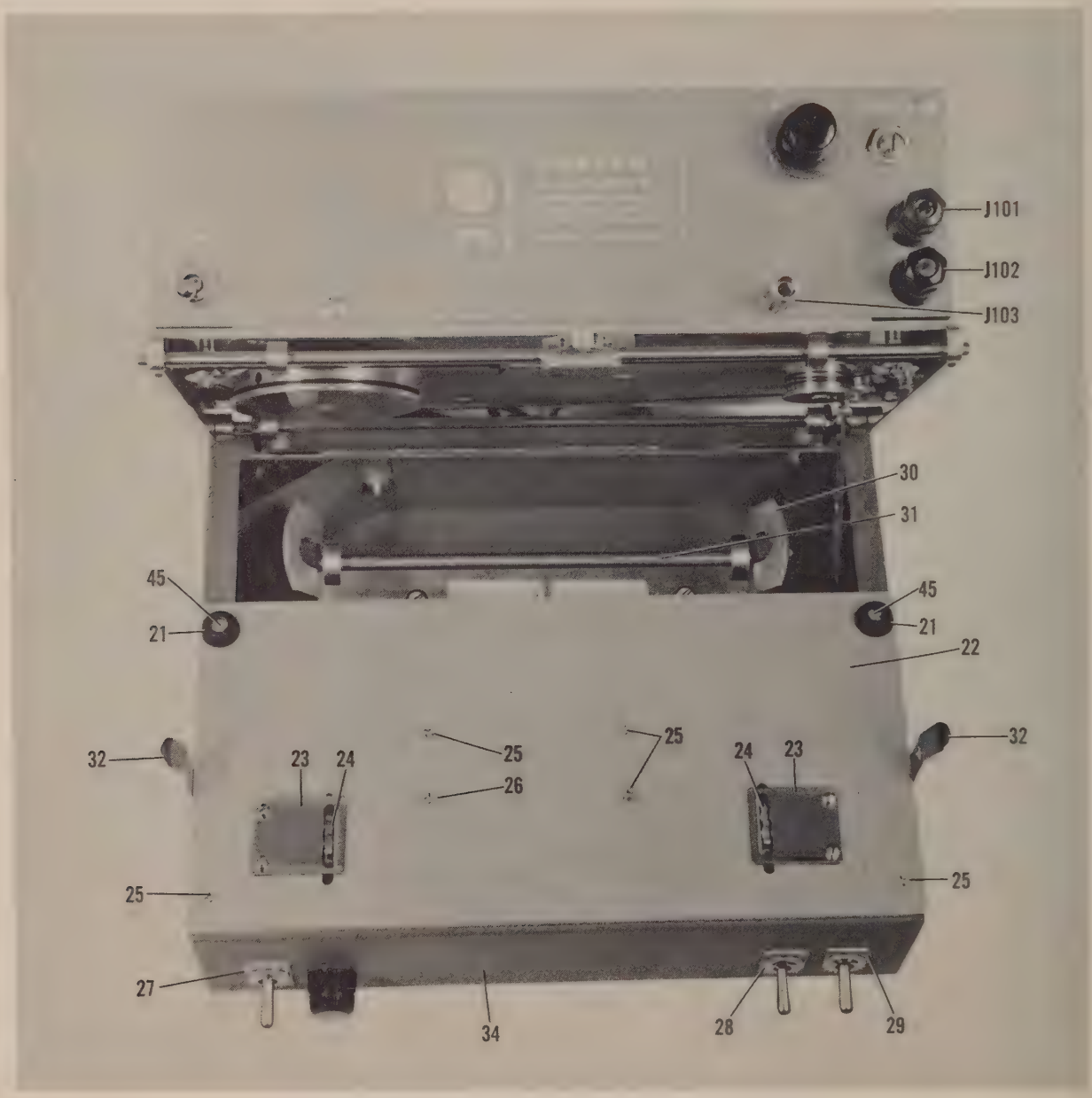


Figure 29. Chart Drive Unit Mechanical Parts

ELECTRICAL PARTS - SERVO UNIT

Electrical parts are called out by circuit designation on schematic diagrams and on Figures 30, 31, 32, and 33.

Circuit Designation	Model Used On	Part No.	Description	Manufacturer's No.
C101	50, 100 mv.	410 08 01 052	0.25 μfd, 200V	
	10 mv.	410 08 01 054	1.0 μfd, 200V	
C102	50, 100 mv, 2-1/2 sec.	410 08 01 052	0.25 μfd, 200V	
	50, 100 mv, 1 sec.	410 08 01 054	1.0 μfd, 200V	
	10 mv, 1, 2-1/2 sec.	410 08 01 054	1.0 μfd, 200V	
C103	50, 100 mv.	410 11 01 015	0.01 μfd, 500V	CRL-GMV
	10 mv.	410 07 20 011	0.02 μfd, 400V	CD-ST4S2
C104	10, 50, 100 mv.	410 01 01 105	50 μfd, 6V	CD-BBR50-6
C105	50, 100 mv.	410 11 01 015	0.01 μfd, 500V	CRL-GMV
	10 mv.	410 07 02 005	0.01 μfd, 400V	CD-PJ4S1
C106A,B, C,D	10, 50, 100 mv.	410 01 02 020	20-20-20 μfd/400V 20/25V	CD-UP22245C
C107	50, 100 mv.	410 11 01 015	0.01 μfd, 500V	CRL-GMV
	10 mv.	410 07 02 005	0.01 μfd, 400V	CD-PJ4S1
C108	10, 50, 100 mv.	410 01 01 105	50 μfd, 6V	CD-BBR 50-6
C109	10, 50, 100 mv., 60 cps	410 07 20 011	0.02 μfd, 400V	CD-ST4S2
	10 mv., 50 cps		0.01 μfd, 400V	
C110	10 mv. only	410 07 02 008	0.015 μfd, 400V	Sprague 4TM-S15
C111	10 mv. only	410 07 02 005	0.01 μfd, 400V	CD-PJ4S1
C112	10 mv. only	410 07 03 001	0.001 μfd, 600V	CD-PJ6D1
C113	10, 50, 100 mv.	410 01 01 039	8 μfd, 450V	CD-BR845
C114	10, 50, 100 mv.	410 01 01 039	8 μfd, 450V	CD-BR845
C115	50, 100 mv. only	410 07 20 011	0.02 μfd, 400V	CD-ST4S2
C116	50, 100 mv. only	410 07 02 005	0.01 μfd, 400V	CD-PJ4S1
C117	10, 50, 100 mv. (isolated input only)	410 08 01 054	1.0 μfd, 200V	CD-MP2W1

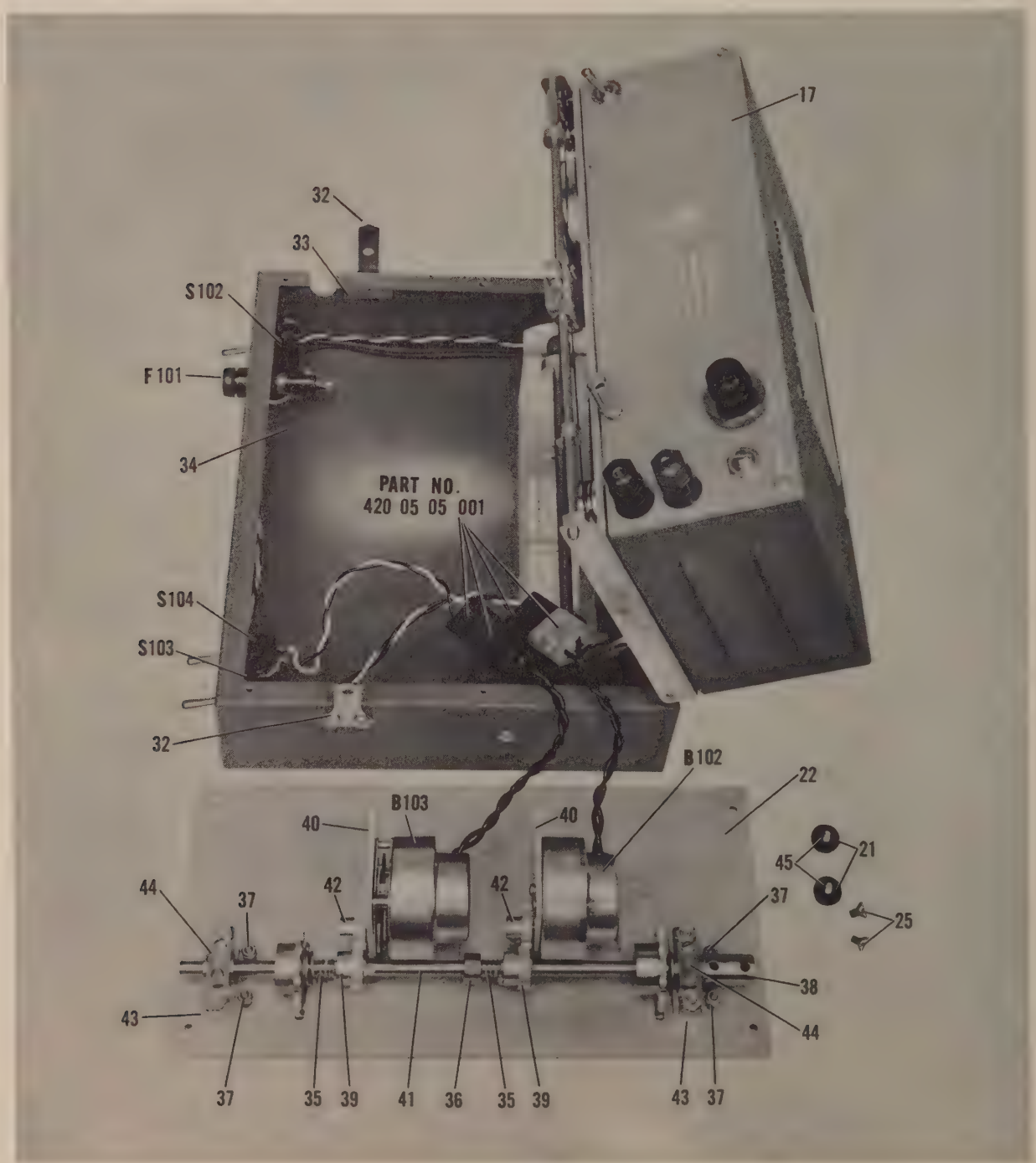


Figure 30. Electrical and Mechanical Parts Numbering

ELECTRICAL PARTS - SERVO UNIT (Cont)

Electrical parts are called out by circuit designation on schematic diagrams and on Figures 30, 31, 32, and 33.

Circuit Designation	Model Used On	Part No.	Description	Manufacturer's No.
R101	50, 100 mv.	464 01 01 050	1 meg, 1/2 watt pot. carbon	IRC-RQ-11-137
	10 mv.	464 01 01 051	0.25 meg., 1/2 watt pot. carbon	IRQ-RQ-11-130
R102	10, 50, 100 mv.	464 01 02 001	5K, 2 watt pot.	Allen-Bradley
R103	10, 50, 100 mv.	464 01 05 017	1.5K, 2 watt pot.	Clarostat A-43-1500
R104	10, 50, 100 mv.	464 02 01 010	5K, 1/2% lin. 5% acc.	Helipot SC-494 Spectrol Mod 850-48
R105	10 mv.	463 01 04 003	910 Ω , 1/2 watt 1%	Electra DC-1/2A
	50 mv. (2 resistors in parallel)	463 01 04 001	10K, 1/2 watt 1%	Electra DC-1/2A
	100 mv. (1 resistor)	463 01 04 001	10K, 1/2 watt 1%	Electra DC-1/2A
R106	10, 50, 100 mv.	463 01 04 002	47K, 1/2 watt 1%	Electra DC-1/2A
R107	10, 50, 100 mv.	463 01 00 001	100K, 1/2 watt 10%	Allen-Bradley
R108	10, 50, 100 mv.	463 01 00 001	470K, 1/2 watt 10%	Allen-Bradley
R109	10, 50, 100 mv.	463 01 00 001	4.7K, 1/2 watt 10%	Allen-Bradley
R110	10, 50, 100 mv.	463 01 00 001	220K, 1/2 watt 10%	Allen-Bradley
R111	10 mv.	463 01 00 001	470K, 1/2 watt 10%	Allen-Bradley
	50, 100 mv.	463 01 00 001	1 meg., 1/2 watt 10%	Allen-Bradley
R112	10, 50, 100 mv.	463 01 00 001	330K, 1/2 watt 10%	Allen-Bradley
R113	10, 50, 100 mv.	463 01 00 001	4.7K, 1/2 watt 10%	Allen-Bradley
R114	10 mv.	463 01 00 001	470K, 1/2 watt 10%	Allen-Bradley
	50, 100 mv.	463 01 00 001	1 meg., 1/2 watt 10%	Allen-Bradley
R115	10 mv.	463 01 00 001	330K, 1/2 watt 10%	Allen-Bradley
	50, 100 mv.	463 01 00 001	220K, 1/2 watt 10%	Allen-Bradley
R116	10 mv.	463 01 00 001	4.7K, 1/2 watt 10%	Allen-Bradley
	50, 100 mv.	463 01 00 001	1K, 1/2 watt 10%	Allen-Bradley
R117	10, 50, 100 mv.	463 01 00 001	470K, 1/2 watt 10%	Allen-Bradley
R118	10, 50, 100 mv.	463 03 01 004	500 Ω , 5 watt WW	1RC-RQ-11-137

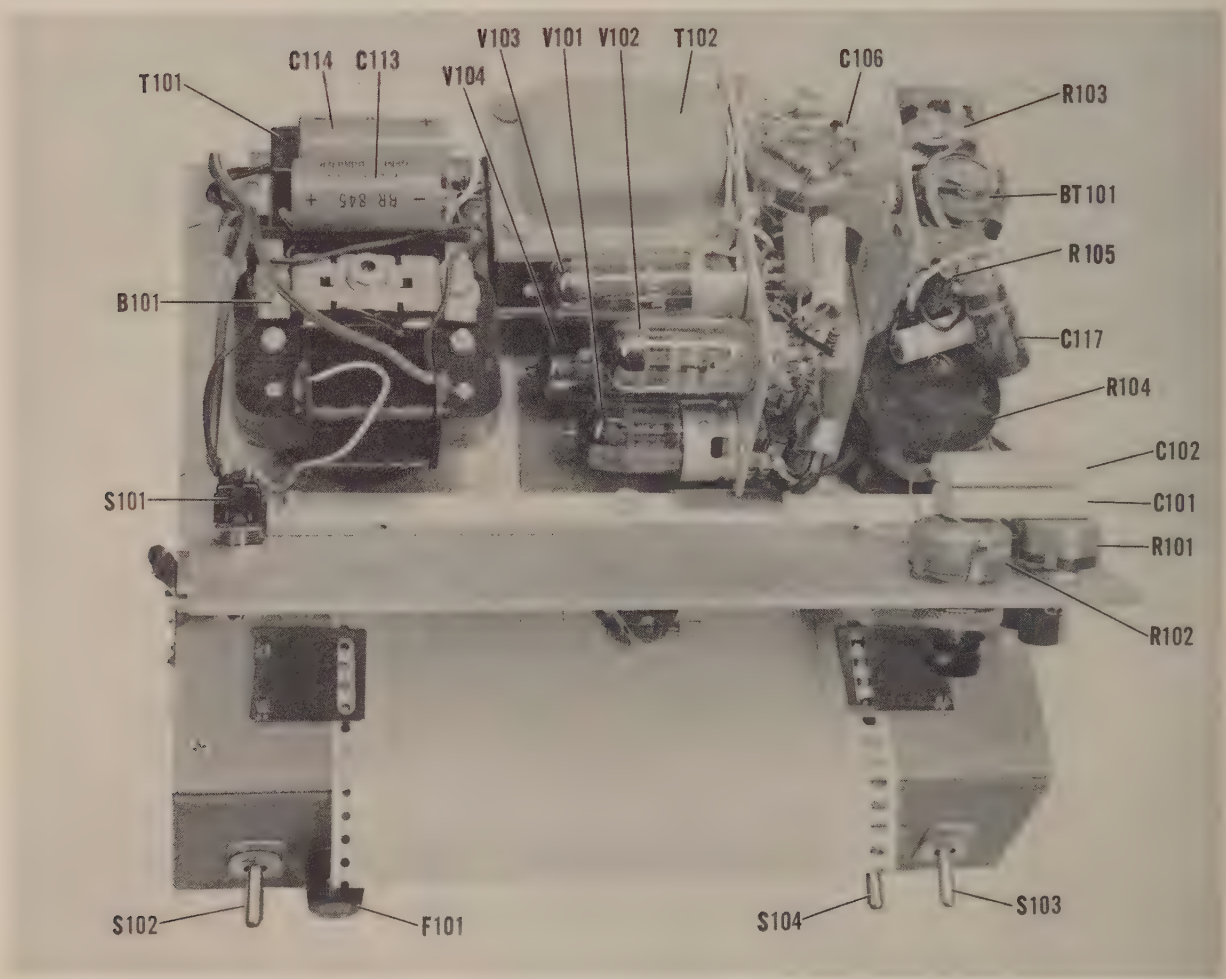


Figure 31. Electrical Parts Numbering

ELECTRICAL PARTS - SERVO UNIT (Cont)

Electrical parts are called out by circuit designation on schematic diagrams and on Figures 30, 31, 32, and 33.

Circuit Designation	Model Used On	Part No.	Description	Manufacturer's No.
R119	10 mv.	463 01 00 001	47K, 1/2 watt 10%	Allen-Bradley
	50, 100 mv.	463 01 00 001	100K, 1/2 watt 10%	Allen-Bradley
R120	10, 50, 100 mv.	463 01 00 001	22K, 1/2 watt 10%	Allen-Bradley
R121	10, 100 mv.	463 01 00 001	470K, 1/2 watt 10%	Allen-Bradley
	50 mv.	463 01 00 001	1 meg., 1/2 watt 10%	Allen-Bradley
R122	10 mv. only	463 01 00 001	10K, 1/2 watt 10%	Allen-Bradley
R123	10 mv. only	463 01 00 001	1 meg., 1/2 watt 10%	Allen-Bradley
B101	10, 50, 100 mv., 60 cps	940389	Balancing motor	Special
	10, 50, 100 mv., 50 cps	940426	Balancing motor	Special
BT101	10, 50, 100 mv.	401 07 00 002	Mercury Reference Cell	Mallory RM-3
T101	10, 50, 100 mv.	900766	Output Transformer	Special
T102	10, 50, 100 mv.	900767	Power Transformer	Special
D101	10, 50, 100 mv.	458 01 01 001	Selenium Rectifier	Selectron 1M1
S101	10, 50, 100 mv.	469 02 00 025	Servo "on-off" switch	Carling 110B-73
J101	10, 50, 100 mv.	471 01 00 001	Input Terminal (Red)	Superior DF-30
J102	10, 50, 100 mv.	471 01 00 002	Input Terminal (Black)	Superior DF-30
J103	10, 50, 100 mv. (Isolated Input Only)		Ground Terminal	
V101	10, 50, 100 mv.	480 05 00 010	12AX7 Vacuum Tube	
V102	10, 50, 100 mv.	480 05 00 010	12AX7 Vacuum Tube	
V103	10, 50, 100 mv.	480 07 00 003	6AQ5 Vacuum Tube	
V104	10, 50, 100 mv.	480 18 00 012	6X4 Vacuum Tube	
Servo Line Cord (See Fig. 33)	10, 50, 100 mv.	900758-2	Servo Line Cord	

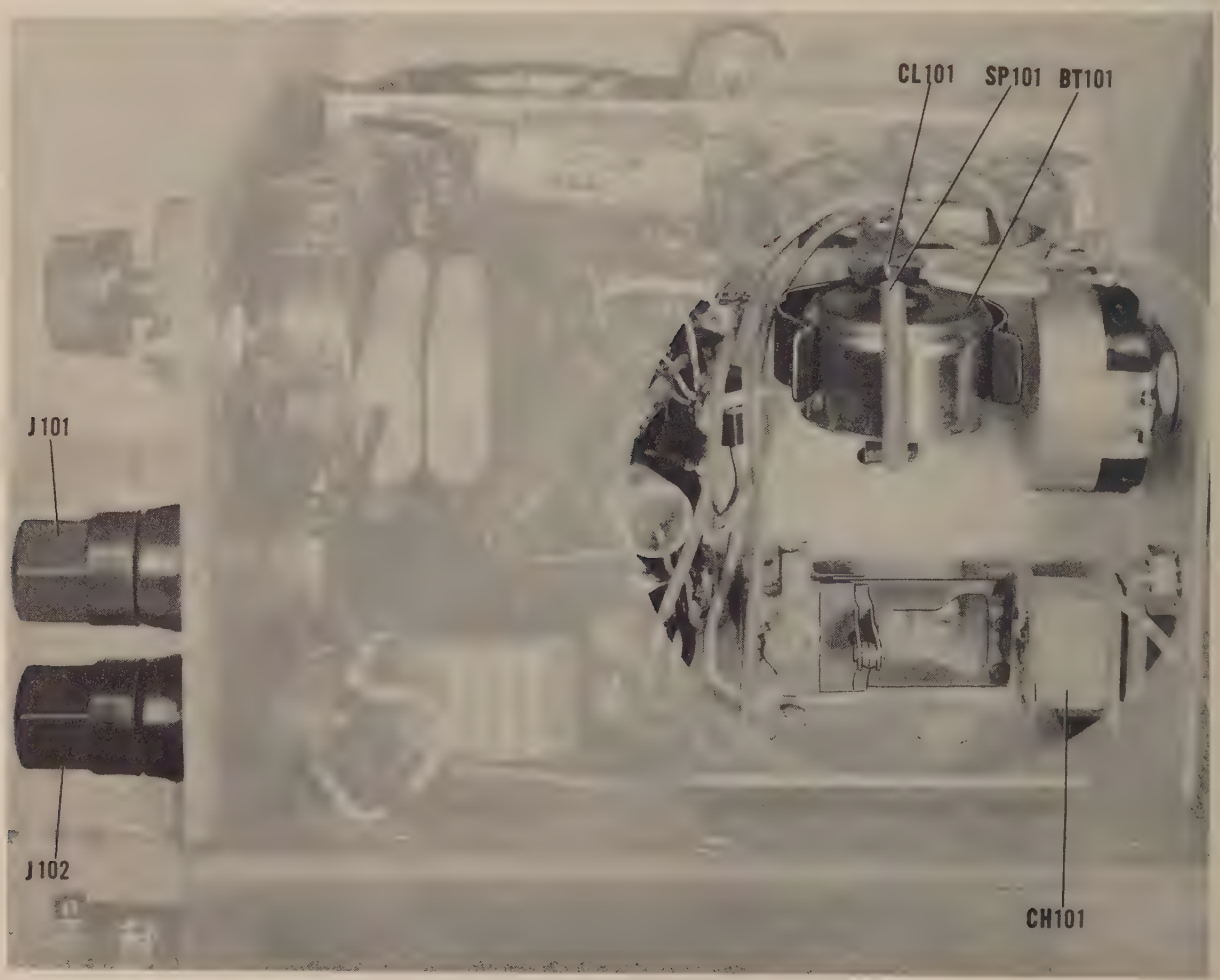


Figure 32. Electrical and Mechanical Parts Numbering

ELECTRICAL PARTS - CHART DRIVE UNIT

Electrical parts are called out by circuit designation on schematic diagrams and on Figures 30, 31, 32, and 33.

Circuit Designation	Model Used On	Part No.	Description	Manufacturer's No.
J101		420 06 01 006	A.C. receptacle for servo	Amphenol 61M1P-61F
S102	1, 2 speeds	469 02 00 025	Power Switch	Carling 110B-73
S103	1 speed	469 02 00 025	Chart Switch	Carling 110B-73
	2 speeds (before ser. #1051)	469 02 00 025	Chart Hi Switch	Carling 110B-73
	2 speeds (after ser. #1050)	469 02 00 050	Chart Hi-Lo Switch	JBT-ST42E
S104	2 speeds only (before ser. #1051)		Chart Lo Switch	
T103 (See Fig. 3)	50 cps (all)	469 02 00 025	Line Autotransformer	Triad N1X
	60 cps (230/115 volts only)	469 02 00 025	Line Autotransformer	Triad N1X
Chart Drive Line Cord (See Fig. 33)		900758-1	Chart Drive Line Cord	
Connector (See Fig. 30)	1 speed, 2 required 2 speeds, 4 required	420 05 05 001	Connector	Amphenol 80-850
CL-101	10, 50, 100 mv.	901683	Reference Cell Holder Assy.	
SP-101	10, 50, 100 mv.	435 11 01 002	Reference Cell Holder Spring	
B102,B103	NOTE: Parts listed below are motors only. For complete chart drive motor assembly, including motor, mounting bracket, gear and line plug, see data sheet facing page 2.			
	60 cps 1"/hr.	450 04 01 005	Motor only	Bristol 6 RPD
	60 cps 4"/hr.	450 04 01 006	Motor only	Bristol 1 RPH
	60 cps 16"/hr.	450 04 01 009	Motor only	Bristol 4 RPH
	60 cps 40"/hr.	450 04 01 012	Motor only	Bristol 1/6 RPM
	60 cps 2"/min.	450 04 01 015	Motor only	Bristol 1/2 RPM
	60 cps 4"/min.	450 04 01 018	Motor only	Bristol 1 RPM
	60 cps 8"/min.	450 04 01 019	Motor only	Bristol 2 RPM
	60 cps 16"/min.	450 04 01 021	Motor only	Bristol 4 RPM
	50 cps 1"/hr.	450 05 01 005	Motor only	Bristol 6 RPD

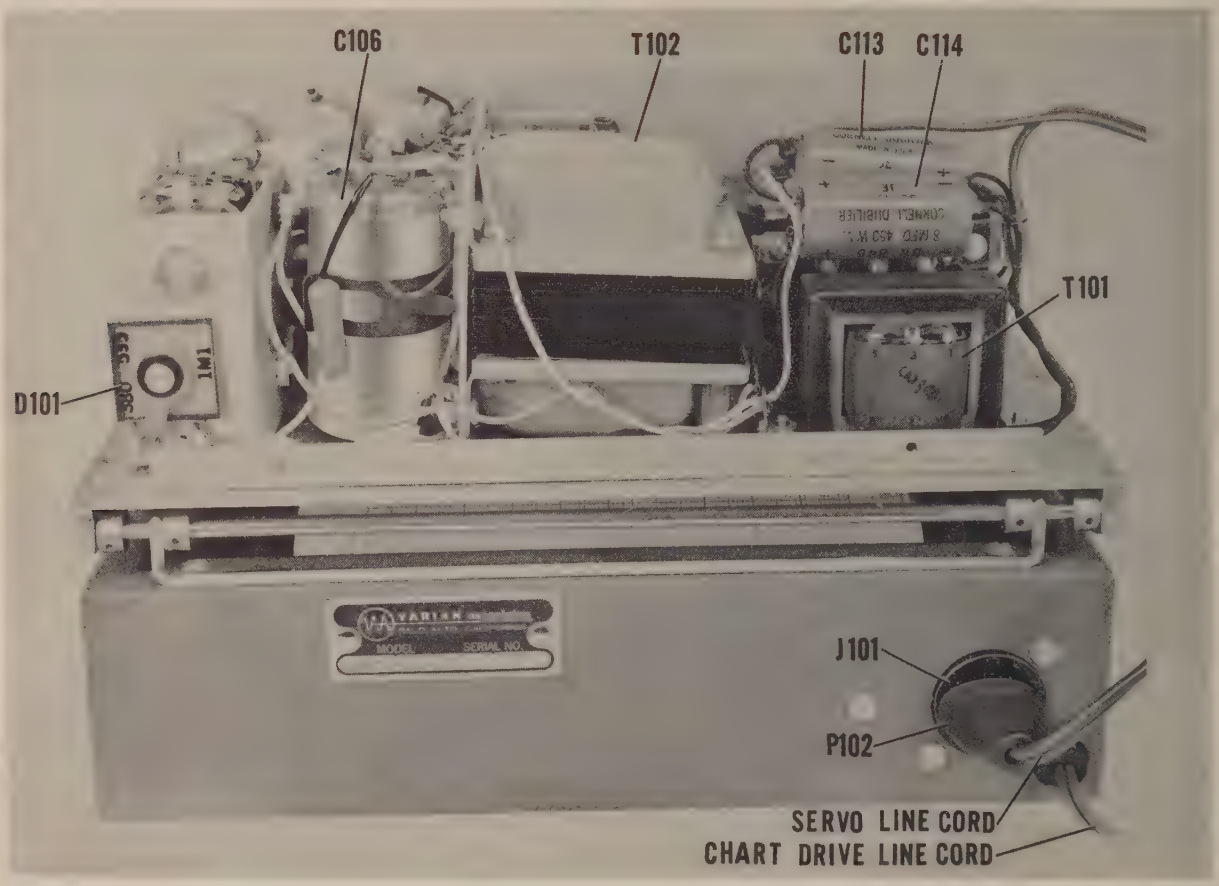
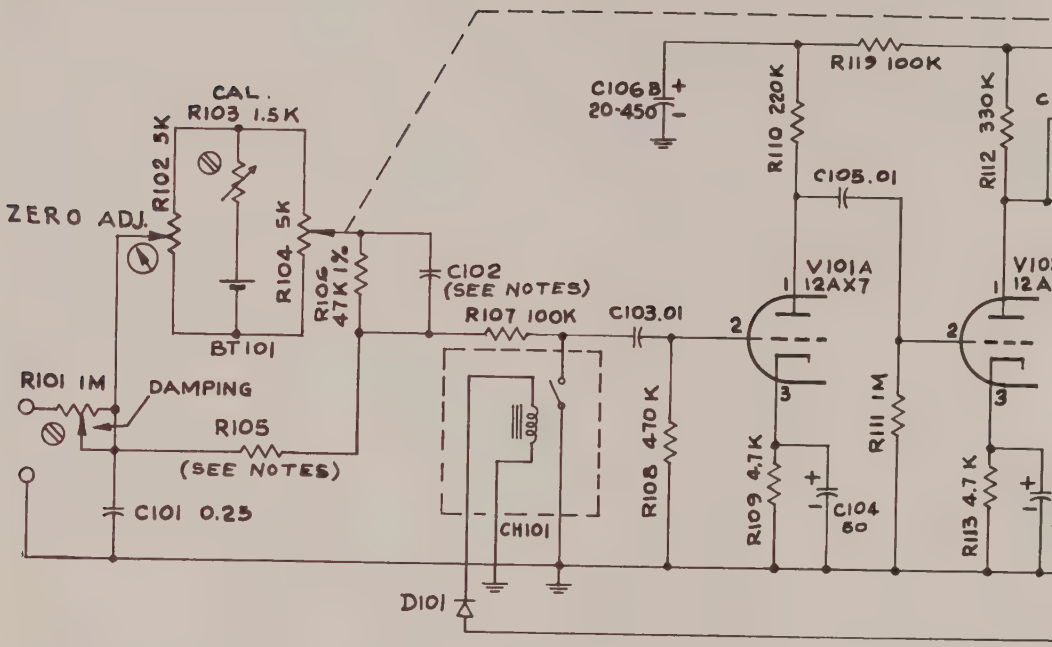


Figure 33. Electrical Parts Numbering

ELECTRICAL PARTS - CHART DRIVE UNIT (Cont)

Circuit Designation	Model Used On	Part No.	Description	Manufacturer's No.
B102,B103 (Cont)	NOTE: Parts listed below are motors only. For complete chart drive motor assembly, including motor, mounting bracket, gear and line plug, see data sheet facing page 2.			
	50 cps 4"/hr.	450 05 01 006	Motor only	Bristol 1 RPH
	50 cps 16"/hr.	450 05 01 009	Motor only	Bristol 4 RPH
	50 cps 40"/hr.	450 05 01 012	Motor only	Bristol 1/6 RPM
	50 cps 2"/min.	450 05 01 015	Motor only	Bristol 1/2 RPM
	50 cps 4"/min.	450 05 01 018	Motor only	Bristol 1 RPM
	50 cps 8"/min.	450 05 01 019	Motor only	Bristol 2 RPM
	50 cps 16"/min.	450 05 01 021	Motor only	Bristol 4 RPM



NOTES:

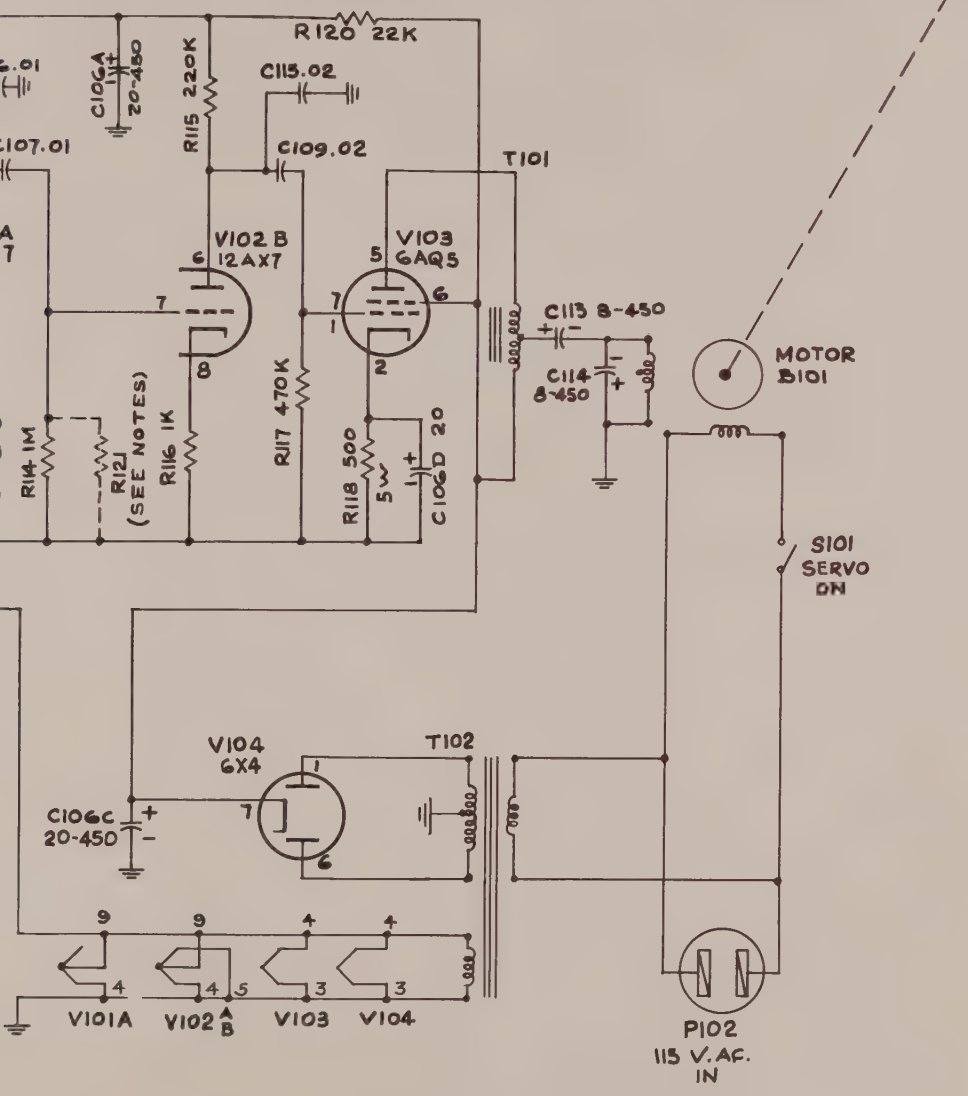
ALL CAPACITOR VALUES IN MFD UNLESS NOTED.

ALL RESISTOR VALUES IN OHMS & ½ WATT UNLESS NOTED.

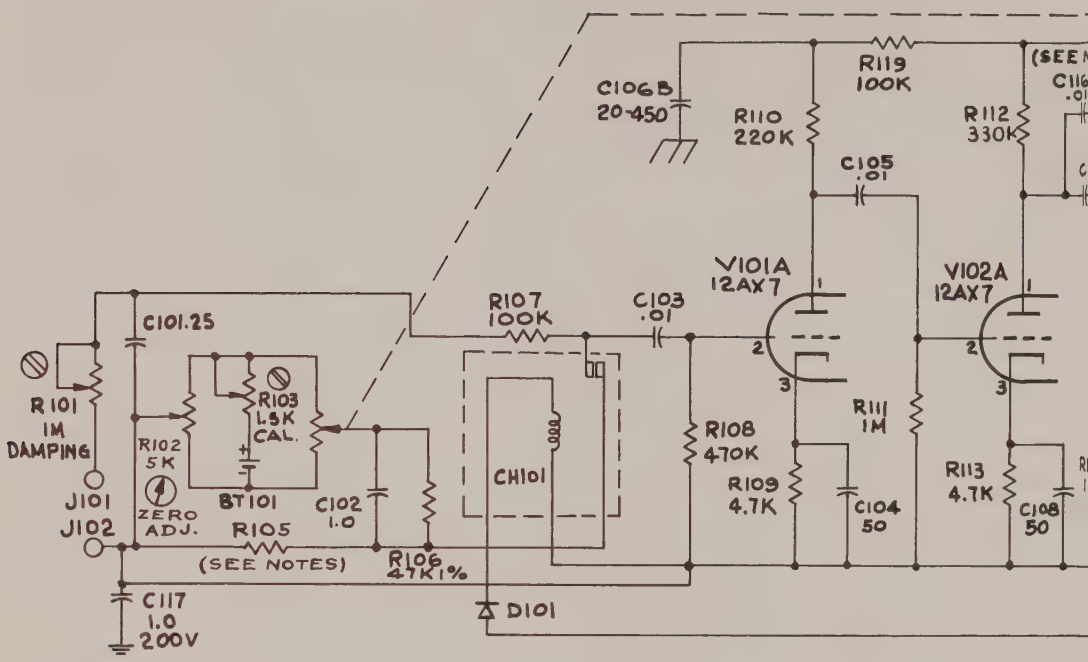
CIRCUIT SYMBOL	100 MV. 2½ SEC	100 MV 1 SEC	50 MV 2½ SEC	50 MV 1 SEC
R105	10K 1%	10K 1%	5K 1%	5K 1%
C102	.25	1.0	.25	1.0
R121	FACTORY ADJ, 470 K NOM.		FACTORY ADJ, 1 MEG. NOM.	

FIG. 34

MEASURING CIRCUIT & AMPLIFIER
50, 100 MV. INSTRUMENTS WITH N
INPUT BEFORE SERIAL N



SCHEMATIC
ON-ISOLATED
0. 1051



NOTES

ALL CAPACITOR VALUES IN MFD UNLESS NOTED.

ALL RESISTOR VALUES IN OHMS AND ½ WATT UNLESS NOTED.

⏚ DENOTES AMPLIFIER CHASSIS

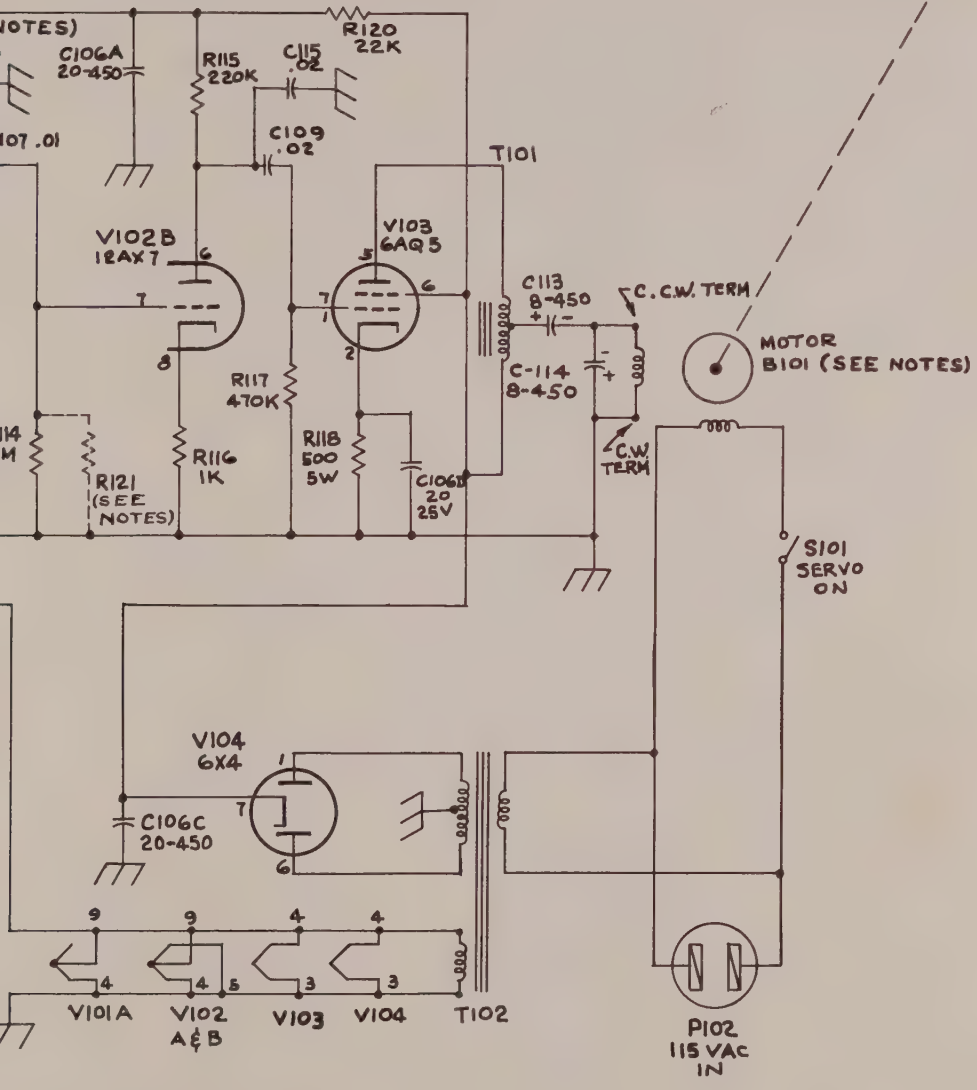
⏚ DENOTES CASE OF INSTRUMENT

CIRCUIT SYMBOL	60 CPS. INSTRUMENTS				50 CPS INSTRUMENTS	
	100 MV 2½ SEC	100 MV 1 SEC	50 MV 2½ SEC	50 MV 1 SEC	100 MV 2½ SEC	100 MV 1 SEC
C102	.25	1	.25	1	.25	1
C116	.01	.01	.01	.01	SHUNTED WITH .02	SHUNTED WITH .02
R105	10K 1%	10K 1%	5K 1%	5K 1%	10K 1%	10K 1%
R121	FACTORY ADJUST 470K NOMINAL		FACTORY ADJUST 1 MEG NOMINAL		FACTORY ADJUST 470K NOMINAL	
B101	VARIAN PART NO. 940389				VARIAN PART NO. 940426	

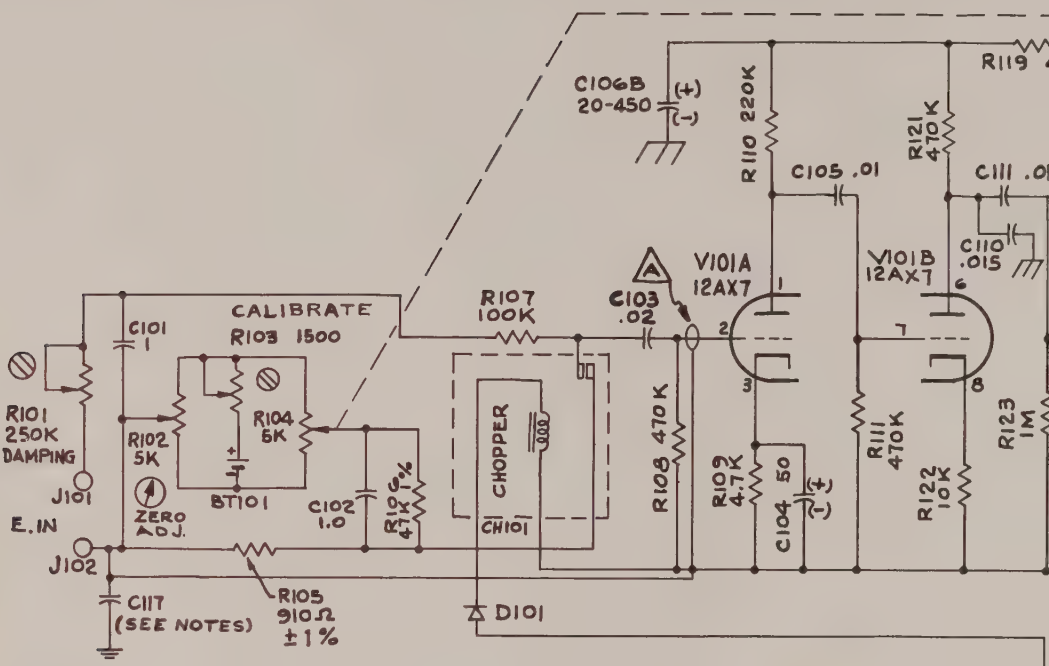
FIG.

MEASURING CIRCUIT AND AM

ALL 50, 100 MV INSTRUMENTS



35
PLIFIER SCHEMATIC
WITH ISOLATED INPUT



NOTES:

ALL CAPACITOR VALUES IN MFD. UNLESS NOTED.

ALL RESISTOR VALUES IN OHMS AND ½ WATT UNLESS NOTED.

DENOTES AMPLIFIER CHASSIS.

DENOTES INSTRUMENT CASE.

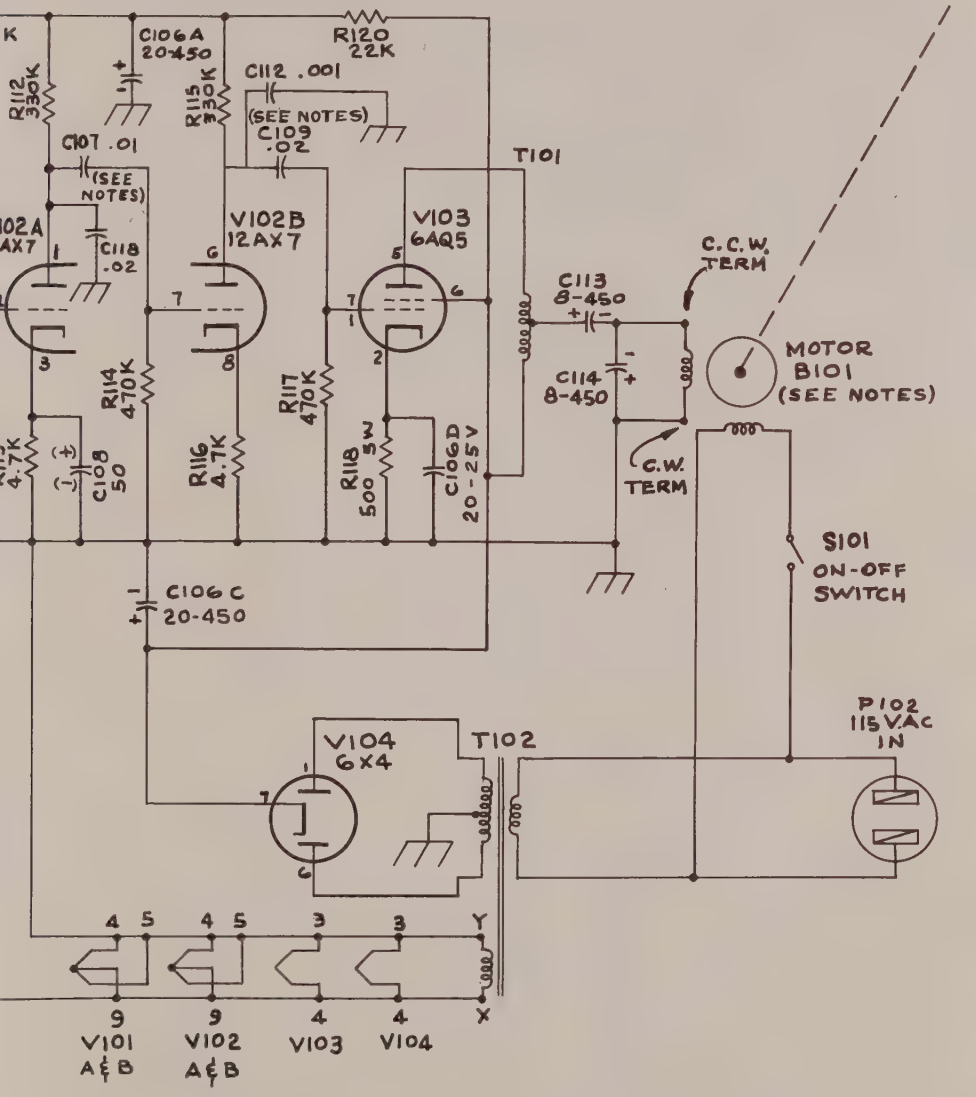
(A) GROUND END OF SHIELD MUST BE GROUNDED AT J102.

CIRCUIT SYMBOL	60 CPS INSTRUMETS				50 CPS INSTRUMENTS	
	ISOLATED INPUT		NON-ISOLATED INPUT		ISOLATED INPUT	
	10 MV. 2½ SEC.	10 MV 1 SEC.	10 MV 2½ SEC.	10 MV 1 SEC.	10 MV 2½ SEC.	10 MV 1 SEC.
C102	FACTORY ADJUST. 1 MFD. NOMINAL				FACT. ADJ. 1 MFD. NOM.	
C109	.02	.02	.02	.02	.01	.01
C117	1.0	1.0	REPLACED WITH JUMPER TO CASE GROUND.		1.0	1.0
C118	NOT USED IN 60 CPS INSTR.				.02	.02
B101	VARIAN PART NO. 940389				VARIAN PART NO. 940426	

FIG

MEASURING CIRCUIT AN

ALL 10 MV. 6-10


R112 330K
C106A 20-450
R115 330K
C112 .001
(SEE NOTES)
R120 22K
C107 .01
(SEE NOTES)
C109 .02
T101
V102A 12AX7
C118 .02
V102B 12AX7
V103 6AQ5
C.C.W. TERM
C113 8-450
C114 8-450
MOTOR B101 (SEE NOTES)
R114 470K
R117 470K
C108 50
R116 4.7K
R118 500 5W
C106D 20-25V
C.W. TERM
S101 ON-OFF SWITCH
C106C 20-450
P102 115V.AC IN
V104 6X4
T102
4 5 4 5 3 3
9 9 4 4
V101 A&B
V102 A&B
V103
V104

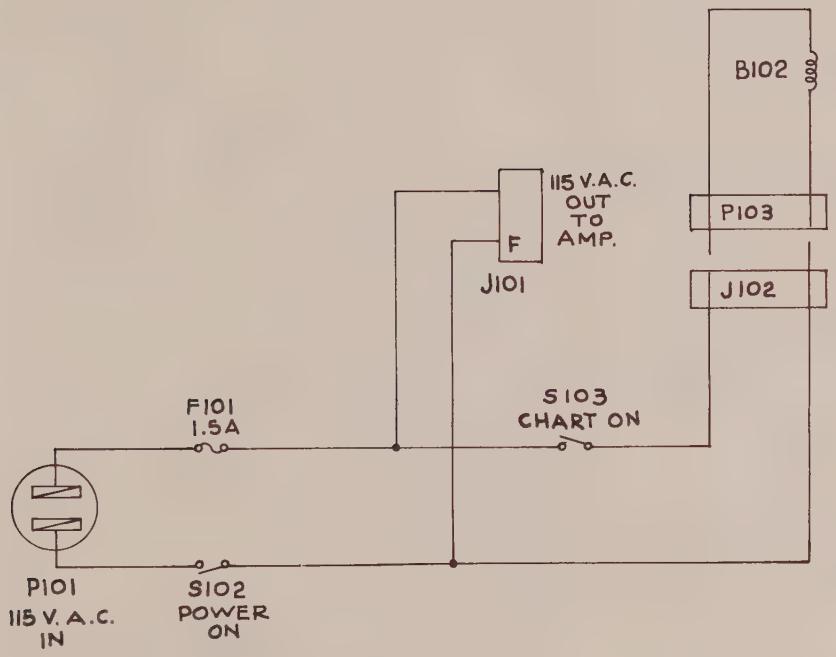
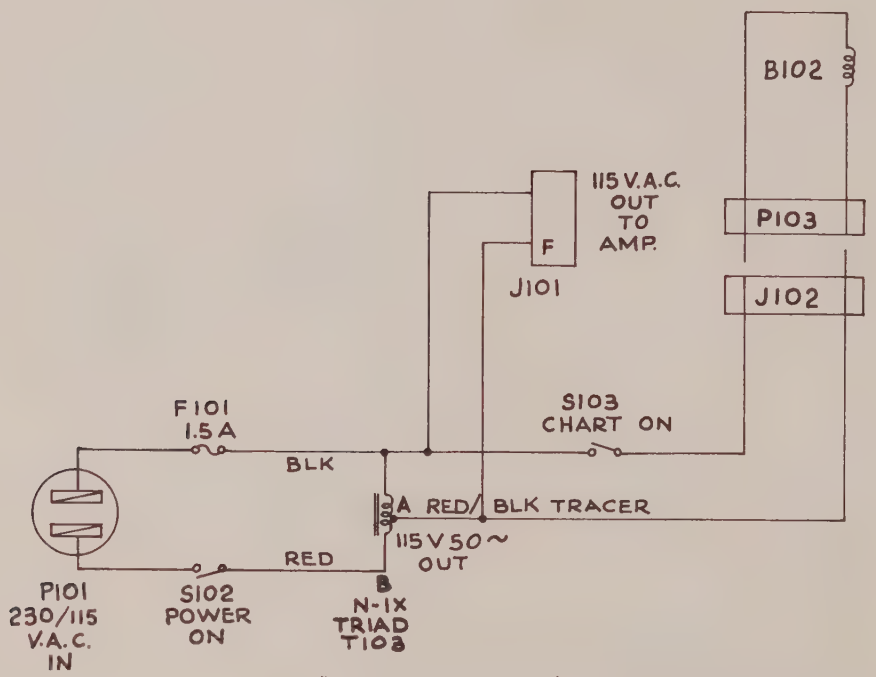


FIG. 37
ALL ONE-SPEED DRIVE UNITS
FOR 115 V.A.C. ONLY



LINE VOLTAGE RANGE	T103 CONNECTIONS
220-240 VOLTS	AS SHOWN
250-270 VOLTS	BLACK TO S102 RED TO F101 & S103
110-120 VOLTS	MOVE J101, J102 LEADS FROM POINT (A) (RED/BLK T103 LEAD) TO POINT (B) (RED T103 LEAD) SEE FIG. 3, p. 4

FIG. 38
ONE-SPEED CHART DRIVE UNITS FOR 230/115 V.A.C., 50 OR 60 CPS. SERIAL NO. 1051 AND ABOVE

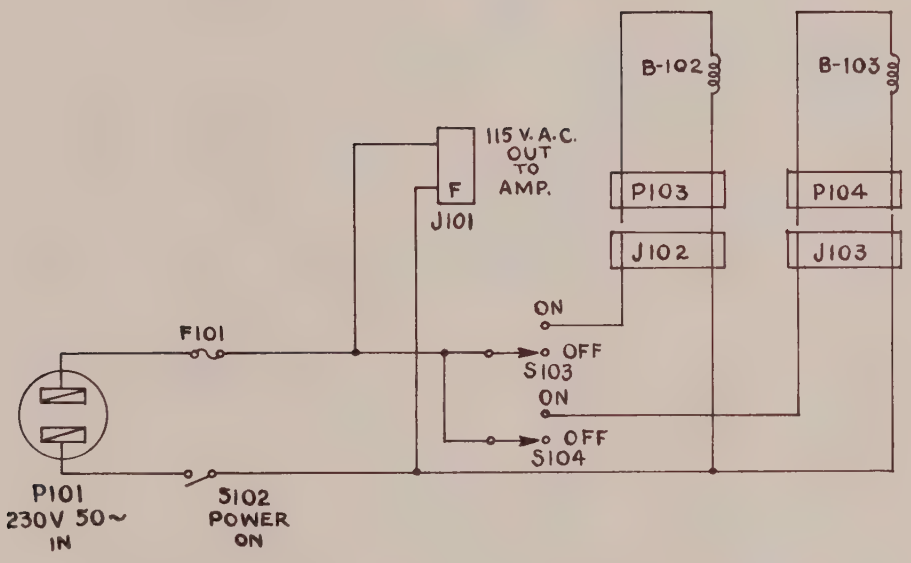


FIG. 39
2 SPEED CHART DRIVE UNITS FOR 115 V.A.C. ONLY
SERIAL NO'S. 1 THROUGH 1050

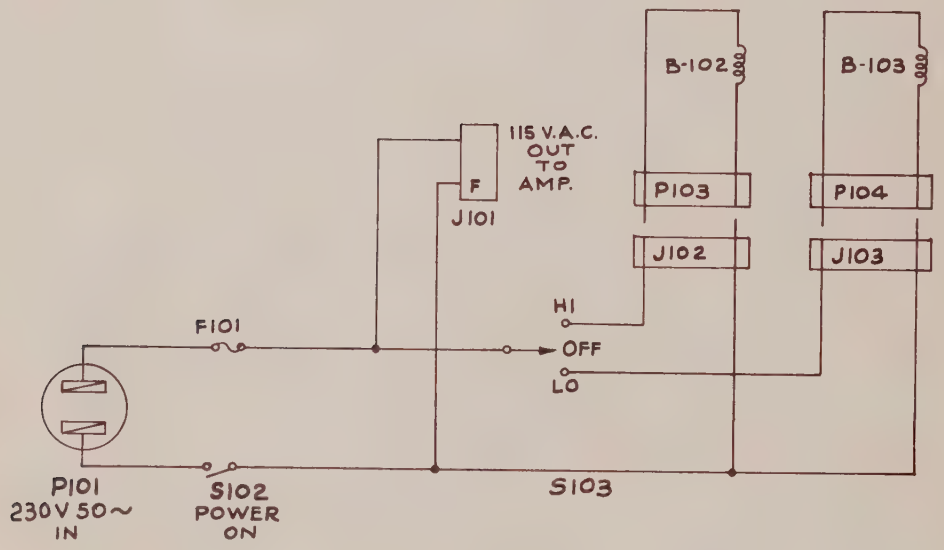
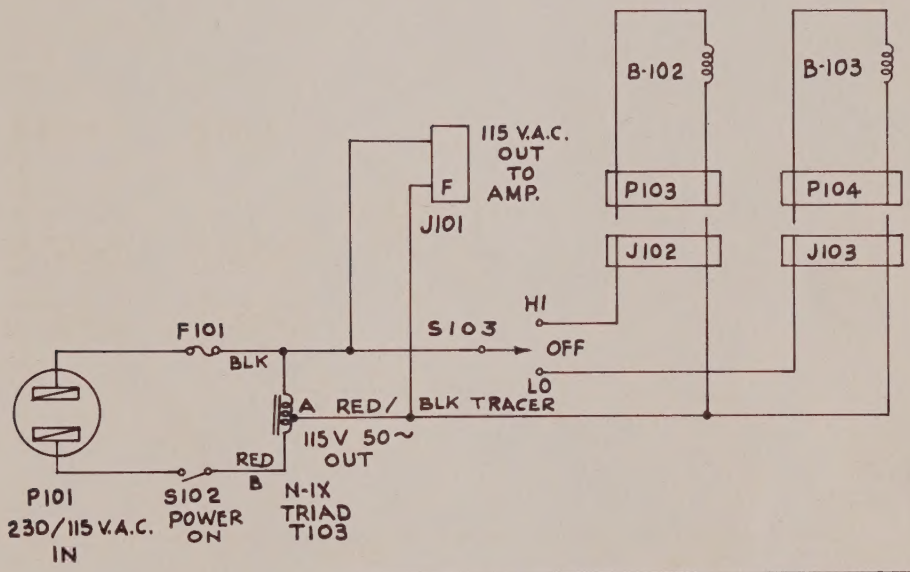


FIG. 40
2 SPEED CHART DRIVE UNITS FOR 115 V.A.C. ONLY
SERIAL NO. 1051 AND ABOVE



LINE VOLTAGE RANGE	T103 CONNECTIONS
220-240 VOLTS	AS SHOWN
250-270 VOLTS	BLK TO S102. RED TO F101 AND S103
110-120 VOLTS	MOVE J101, J102, J103 LEADS FROM POINT Ⓐ (RED/BLK T103 LEAD) TO POINT Ⓑ (RED T103 LEAD) SEE FIG. 3, p.4

FIG. 41
2 SPEED CHART DRIVE UNITS FOR 230/115 V.A.C.
50 OR 60 CPS. SERIAL NO. 1051 AND ABOVE

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